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ABSTRACT

The purpose of this project was to find and make clarifications about the uniqueness and similarities on various aspects of science education programs in Japan, the Republic of Korea, the United States, and the Philippines that could provide the basic considerations on curriculum development. Included are: (1) an introduction to the research; (2) a description of research instruments which measure reasoning skills, process skills, basic science achievement, laboratory skills, out-of-school science experiences, motivation towards sicence processes and love for nature, and science attitude; (3) a comparison of scientific thinking skills in the four countries' secondary school students; (4) descriptions of scientific thinking skills in Japanese elementary school students; (5) the effects of a laboratory-centered inquiry program in American sixth- and seventh-grade students; (6) implications; and (7) a summary. Additional baseline data and some of the test instruments are provided in the appendices; extensive references and more than 80 tables/figures are provided. (YP)

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A STUDY OF COGNITIVE SKILLS AND OTHER RELATED FACTORS IN SCIENCE EDUCATION

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Research Project Report
Grant-in-Aid for Scientific during 1986 to 1988
Project Number: 61450098

March 1989

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A STUDY OF COGNITIVE SKILLS AND OTHER RELATED FACTORS IN SCIENCE EDUCATION

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科学教育における Process Skills, Reasoning 等に関する研究

研究成果の概要

本報告書は、文部省の科学研究費補助金の助成のもとで昭和６１年から６３年にかけて行った「科学教育におけるProcess Skills,Reasoning等に関する研究」の研究成果をまとめたものである。本報告書は、大別して、３部門から構成されている。第１部では、本研究を支える理論的枠組みと研究の全体計画をまとめた。第２部では、本研究で実施した調査問題の開発に関する先行研究の概要をまとめ、それらの信頼性(Reliability)と妥当性(Validity)を検討した。第３部では、実際の児童・生徒を対象にした、理科における知識・理解、科学的思考力、観察・実験能力、学校外での理科的経験、意欲、心情、態度に関する実態調査の結果をまとめた。この実証的研究の部は、以下の４事例研究から構成されている。

1. 中学校生徒（第７・８・９学年）の論理的思考力、プロセス・スキル、理科的経験、意欲、心情、態度に関する実態調査を、日本、アメリカ、韓国、フィリピンの４ヶ国で実施した。異なる文化的社会的背景をもつ４ヶ国の生徒の実態にみられる共通点と差違点を抽出し、横断文化的な考察を加えた。ここでは、学習者を取り巻く文化的環境が異なろうとも、内的な自然認識能力の発達のしかたという点で共通するものがあり、これらの能力は、学校外での理科的経験の度合い、科学の過程に対する意欲、自然に対する心情、理科授業に対する態度と有意な関係があることが明らかになった。

2. 日本の小学校児童（第５・６学年）の論理的思考力、プロセス・スキル、理科的経験、意欲、心情、態度に関する実態調査を実施した。これらの調査結果を、日本の中学校生徒を対象とする同様の調査の結果と対比・対照することによって、発達段階に伴う児童・生徒の変容の実態を明らかにした。ここでは、日本の小学生と中学生では、学校・学年段階が異なろうとも、内的な自然認識能力の発達のしかたという点で共通するものがあり、これらの能力は、学校外での理科的経験の度合い、科学の過程に対する意欲、自然に対する心情、理科授業に対する態度と有意な関係があることが明らかになった。

3. 理科における知識・理解、プロセス・スキル、観察・実験能力を育成するための効果的な教授方法を明らかにすることを目的として、アメリカの生徒（第６・７学年）を対象に、実験的アプローチによる調査を実施した。科学の過程・探究の方法を重視した観察・実験中心の教授方法と伝統的な教科書・講義中心の教授方法の効果を、生徒の学習成果から評価した。その結果、教科書・講義中心の教授方法は、学習者の知識・理解、プロセス・スキル、観察・実験能力の育成に対して、有意な効果を及ぼさないことが明らかになった。

4. 日本の小学校児童（第６学年）を対象に、理科のアチーブメント・テストを実施した。テストの項目は、文部省の学習指導要領に示されている第６学年の理科の目標と内容にそれぞれ対応するものである。ここでは、児童の知識・理解の到達度の評価をもとに、理科カリキュラムの内容構成に関する改善の視点を明らかにした。

これらの研究成果は、学習者の実態にもとづく、よりよい理科のカリキュラム構成を図るための基礎的データを提供するものである。

PREFACE

This report entitled "A Study of Cognitive Skills and Other Related Factors in Science Education" has been made under the support given by the Ministry of Education, Science and Culture of Japan through the Grant-in-Aid for Scientific Research program. The purpose of this research project is to find out and make clarifications about the uniqueness and similarities on various aspects of science education programs in Japan, Republic of Korea, Philippines, and the United States, that could provide the basic considerations on curriculum development that is geared towards improving the learning and teaching process of science in various countries.

It can be stated that various differences exist in various countries with regard to educational policies, regulations, financing, curriculum standard, teacher training, instructional materials, and other matters related to education. Undoubtedly, the existence of differences on the fundamental values, socio-economic issues, public opinions, attitude towards scientific and environmental matters, and expectations on science and technology concerns possessed by the people in various countries has caused tangible variations from one country to the other with regard to the educational goals as well as programs. In like manner, the people from various countries have therefore exemplified varied types of educational practices related to teacher preparation, course offerings, and availability of facilities that could improve the existing school system. These factors could certainly bring about the uniqueness on the characteristics of each country. The existence of this fact may be interpreted to bring about the diversity in the educational characteristics in the different countries worldwide. It is therefore the objective of this study to clarify the uniqueness of science education in countries like Japan, Republic of Korea, Philippines, and the United States in order to foster a clear understanding about matters related on the outcomes of education.

It is worthwhile to note, however, that although the historical and socio-cultural background among countries differ, it would still be possible to find out the commonalities among them in the field of education specifically in the area of science teaching. This probably could be interpreted as a result of the internationalization of science education that has been brought about by the process related to imitation, adaptation, and implantation of various practices in teaching in various parts of the world. The similarities of the developmental stages pattern as exemplified in the cognitive, affective, and psychomotor domains of the learners may have also caused the commonalities of science education in various countries. Through this study, therefore, the clarification of the similarities of science education among the four countries has been made possible.

It was also the purpose of this cooperative research project to obtain the basic baseline data related to various factors and the contributions these could provide to the field of science education. It is therefore the hope of the investigators that the findings of this study could be used in the analysis, synthesis, and assessment of the various science education programs worldwide during the process of curriculum development, implementation and evaluation. The investigators also hope that this report would be used in the programs in improving the logical thinking skills, science process skills, and understanding on the various scientific knowledge such as those acquired through the inquiry approach of teaching which requires the utilization of hands-on and other practical activities.

The investigators sincerely extend their heartfelt thanks and gratitude to the Ministry of Education, Science and Culture of Japan for the financial support given to the project, and to all the research team members, administrators, teachers, and students who participated in the cooperative project, and to all those who in one way or the other has made possible the completion of this report. The investigators sincerely hope that this cooperative research project that included some student samples from four countries could bring about mutual understanding, trust, and friendship through the task of exchanging educational ideas so that the further improvement of the quality of education could be enhanced, thus making possible the achievement of educational excellence worldwide.

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RESEARCH GRANT

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Chapter I

INTRODUCTION

The rapid pace of development nowadays can be observable through the existence of various modern inventions that made the life of human beings much easier compared to the former generations. This development has been brought about, undoubtedly by the various contributions resulting from the field of science and technology. It would therefore be necessary for the people to concentrate on the further development in the society through the promotion of understanding of the people towards the advancement being made through science and technology. Education, therefore, plays a very important role on the process so that the development made could actually match with the capacity of the people to cope with these multifarious changes.

Due to the desire of educators to improve the educational process, science educators along with other experts of all fields of learning had concentrated their efforts towards the improvement of the science curriculum. Educators tried to outline curriculum changes geared towards the further development of the teaching and learning process in the various school levels. Despite of these efforts, however, educators still are encountering a lot of problems related to the proper implementation of well-prepared curricular changes. The objectives that were desired commonly are not attained by the

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educators. They at times experienced the difficulty of attaining such objectives as promoting the ability in and attitude of all the learners toward making inquiries about nature through observations and experimentations as well as enhancing their understanding of natural things and phenomena, so as to foster a valuable capacity to appreciate nature. Not all of the learners acquired the desired capacity to deal with the cognitive, psychomotor, and affective domains necessary to really appreciate the different areas in science.

For thoughtful educators, developing the scientific thinking skills and the scientific knowledge of the learners can become one of the primordial aims of science education at any school level in any country because science is precisely needed in meeting the societal needs of the 21st century. The concentrated efforts of educators from various nations would be necessary in order to enable the effective acquisition of valuable information that could help improve the science curricula on a global scale. This aim of science education share a commonality with the main essence of education that is to provide the young people with chances to acquire the necessary skills, knowledge, understanding, and attitude which enable them to act with decorum as successfully functioning adults and accountable constituent of civilization. The data gathered from Japan, Republic of Korea, United States, and the Philippines about the scientific thinking skills and other related factors on science education would be to a certain degree help in the realization of the aim of improving the necessary scientific skills and knowledge of the school learners worldwide.

Most educators of today are aware of the real importance of science in the total education of students at the elementary and secondary school levels. There is an increasing recognition the learners at a certain age are capable of assimilating scientific principles and that it is feasible to nurture the learners' rational thinking capabilities to perform scientific thinking skills which included both reasoning and process skills. It has been found out by Piaget and his collaborators that the cognitive growth in learners follows series of maturity levels within every person has to go through resembling the physical maturation process. The series of maturity levels included proportional, concrete, and formal stages. It was hypothesized by Piaget that the rapid development of the cognitive structure of the learner occurs during the peried they have reached adolescence. It was also stated by Hurd (1978) that the rapid development comes twice, that is, during the first three years and within the ages 10 to 15. These periods comprised the years when the learners are at Grades five to nine of the formal school system in most countries. However, useful these findings about human development are to understanding how and why a student learns science, teachers of learners who are within this period of rapid developmental changes know that exposure to an active science environment does not necessarily ensure their acquisition of scientific literacy. Knowledge about the developmental level of the learners must be within the minds of teachers in order to enhance effective teaching in the field of science.

A. BACKGOUND AND NEED OF THE STUDY

The rapid improvement of science education due to the influx of scientific findings extends into every school level of the formal educational system in many parts of the world. The scientific and technological laboratory extends forward to their homes and communities where the people are living. It can not be denied that the many uses of science affect directly or indirectly the lifestyle of every human being continuously as a result of the multifarious findings coming from modern researches in various fields of science and technology as well as in social fields of studies. It is therefore necessary for every person to be able to acquire at the appropriate age a training in various aspects of science since it consists of both organized and rapidly changing body of knowledge and a way of acquiring, using, and refining the body of knowledge accumulated throughout the years. To be able to deal with the scientific and technological changes, the learners should be equipped with the difficult scientific thinking skills that deals in reasoning and processes in science.

The pre-college levels especially during the secondary school years as a transition point between the elementary school and tertiary institutions is populated predominantly by learners who are characterized as possessing the characteristic progression from concrete to formal stages as revealed by the studies undertaken by Piaget and his colleagues. This level of development suggests the period wherein the capability of the learners to think about abstract ideas has already started and so it would give a chance for teachers to train them with more complex processes of the scientific thinking skills. In order to foster success in enhancing the development of the reasoning skills and science process skills, the teachers must be able to utilize better quality methods and techniques of teaching thereby requiring them to acquire a better quality training. However, teachers are found out to experience inadequacy in determining the real components of scientific thinking skills thereby encountering the failure to sufficiently assess the cognitive development processes of the learners. In the field of science education, it has become a necessity for science teachers to understand what they actually do and be able to make an analysis of the cognitive difficulties of the learners in order to develop effective teaching techniques to help them. It has therefore become necessary for the teachers to acquire the reasoning and process skills possessed by the learners through the use of evaluative techniques using interview techniques or the paper-and-pencil test method.

Researchers who dealt with the study of the development of human beings adhere to the idea that intellectual development, similar to physical and emotional progression, is considered to undergo a gradual growth that is therefore difficult if not impossible to be accelerated greatly. Learners all act within the domains of their abilities, however, these hindrances are more in the younger people. Teachers should therefore know and understand the effect of these hindrances if the learning experiences in science and other subject areas are expected to bring about effective outcomes. The hindrances that occur during the developmental process should be expected to decrease at a certain stage of the life of learners. The teachers should therefore bare on their minds that it is not possible to accelerate developement by artificial means and so they have to consider teaching the learners within the limitations naturally imposed by developmental stage and the time-consuming speed of developmental progression. It was stated by Piaget (1970) that in order to be able to present an adequate motion of learning, a teacher must explain at the start how the learners are able to construct and invent, not simply how he follows or mimics the topics being taught. Teachers should also consider the fact that it is important that they first know and understand what development of the capacity to learn is all about. It was also stated further by Piaget (1970) that accelerating development is certainly possible, however, there is a need to evaluate the process whether it is desirable or simply bringing about harm on the part of the learners. Piaget believed that cognitive and intellectual changes are the outcome of the developmental process in which all the human beings are supposed to experience. It has therefore been theorized by Piaget that cognitive and intellectual changes come along with the process of development and so he concentrated his investigation of the evolutionary process that occur among the learners from the infancy stage until the adolescent stage. The structure of the cognitive process possessed by the human beings could undergo gradual qualitative transformations thereby bringing about cognitive development.

In order to understand the concept of cognitive growth, it was outline by Piaget that human beings commonly pass into periods of intellectual development. These cognitive developmental stages include sensory motor, preoperational thhought, concrete operations, and formal operations. It should be understood that the stages of the process of cognition were construed by Piaget through the use of extrinsic evidence. There is an extrinsic evidence that a learner can select a certain technique in order to solve problems at a given age level. It may be noted that age is not the determinant of reasoning or logical thinking levels of the learners. The chronological age of learners, therefore, simply projects the period wherein learners demonstrate the cognitive reactions that are particularly demonstrated within a given stage. The learner's capacity to control themselves can be considered as a strong determinant of their rate of development and learning. It was specifically stated, however, that learning naturally takes place as a part of structure, and on the other hand development happens by transversely crossing the structures. The development process taking place in a learner at the time he acquires instruction in school for number of years is defined by sequential progression from concrete to formal stages in cognition.

The starting phase of the cognitive development can be traced as exemplified through the behavior of an individual at the outset of the sensory motor phase. This condition exist due to the fact that cognitive behavior at any stage of development originate simultaneously from previous phases of behavioral patterns. The process of intellectual development can be characterized of being the product of behavior accumulation. Within the capacity of an individual to think at the concrete stage, the mental process is naturally prepared for the transformation that would occur during the formal stage characterized as having a continuous characteristic. It could therefore be stated that the existence of developmental stages on the cognitive growth is simply an analytical procedure for rationally depicting the growth of development as a process within a human being in a conclusive form. Concrete and formal, as words signify the abstract condition and thoughts that should therefore be used with precautionary measures for human beings.

The formal stage in human development is of particular interest for science educators at precollge school levels specifically during the later part of elementary schooling and during the early part of secondary education. It has been stated by researchers that a large portion of the concepts being taught at the secondary school science incorporates formal thought processes on the part of the learners so that these can be assimilated by them fully. The findings on the formal stage researches also suggest that a lot of adolescent students actually failed to acquire the capacity to think at the formal level before they reach the age when they can enroll at the college level and in some cases not even after the period. Educators should therefore exert their efforts to help students acquire the capability to deal with the limitations being posed to them by their within the concrete operational structure that can be made through the promotion of formal structures or by transforming various lessons in science into patterns that could be understood by concrete operational thought processes.

The basic characteristics of a learner categorized to be within the period of preoperational thought in his capacity to function only using the mode known as symbolic analysis to understand concepts. The learner at this stage therefore acquires the capacity to represent events on his mind and becomes independent using direct sensory motor actions to direct the behavioral patterns he possess. The learner, at this stage, therefore learns to acquire the capacity to use his mind through the process of perception utilizing his senses rather than the use of logical operations. The seemingly sense distortions do not necessarily pose any confusion within his mind.

The stage of concrete operation is known as the transitional stage between preoperational and formal thought processes. This period is characterized by the capacity of the learner to deal with logical or reasoning operations even though his thinking level can be categorized as within the concrete stage. The learner can therefore successfully deal with the task using physical manipulations of objects. The learner, however, may encounter difficulty dealing with symbolic concepts. At this stage, the learner oftenly deals with reasoning thought processess applicable to solve problems catagorized within the concrete stage. The learner who is still at the concrete operational stage possesses thinking capacity not necessarily centered on himself. The learner can therefore direct perception

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in a diversified manner therefore causing the attainment of transformational thought processes. The learner can therefore deal with the task reversing operational processess. The concepts dealing with conservation are among the most important features in this concrete operational stage. Once the learner has attained the capacity to do concepts in conservation, then he usually overcome the problem concomitant to the process of logical thinking.

It was considered by Piaget that the formal operations stage is the summit of the cognitive thinking process. The learner at this stage posssesses the capacity to solve problems that can be tackled using logical operations. The learner's capacity as measured by the quality of thinking is characterized as its apex when the ability to think formal operations is reached. The learner can therefore do logical operations hypothetically and so his mind is not only filled with thoughts on concrete and other material things in his surroundings.

The learner who has reached the formal thought is known to possess the capacity to solve problems involving tasks such as combinatorial reasoning, proportional reasoning, control of variables, probabilistic reasoning, as well as correlational reasoning. Along with these, the learner should be able to cope with problems related to conservation such as on numbers, substance, length, area, weight, and volume once he has reached the formal stage.

Most science education research has been based on Piaget if it has been based on any developmentalist according to Novak

(1978). Regardless of the worth of these theories, they have much impact on research, although the situation may be changing. The ideas of Bruner and Ausubel can also be considered important on the understanding of the cognitive skills of the learners. Both are known to be very Piagetian even though both sharply disagree with Piaget on some issues. Bruner reanalyzed and gave altered meaning to Piaget's notion of sensory motor, concrete, and formal operations. Bruner dealt on expressing the concepts related to three kinds of knowledge which he categorized as inactive, ikonic, and symbolic. These ideas refer actually to the mental codes or representations made by the learners. The enactive mode of representation has been described as involving physical action, the ikonic phase emphasized imagery and perception, and on the same manner, the symbolic mode primarily is involved during the language acquisition. These phases of the human thinking can be used by the learners any time of need by subjects at any school grade level in which a learner is enrolled in. It can be speculated, however, that the concrete level students would be relatively weaker than the formal level students in the process of representing particular set of knowledge, with particular consideration of the symbolic phase, however this phase could also be dealt by them. On the other hand, the technique utilized by Bruner in enhancing cognitive conflict and consequently related to the resolution of conflict specifically utilizes the young learners' capacity to utilize symbolic representation without the presence of ambiguous concrete contents. It was also emphasized that scientific as well as mathematical knowledge incorporates the utilization of all phases, but the most useful phase has been said to be the symbolic one. The symbolic phase can also be utilized in learning a language and so the representations of knowledge can also be made using the other modes on the cognitive capability of the learners. It has also been discovered, based on the close observation on the learner that the other phases are closer to direct experience whereas the symbolic mode can go beyond direct experience. This is Piaget's form-content differentiation. Actually this differentiation is as old as rationalist philosophy and goes back to Plato. In addition to going beyond the record of past experience, the symbolic phase allows a projection into the potentialities of future experience. Finally, the symbolic phase is the phase of choice for communication of ideas although the ikonic such as pictures and graphs and enactive modes such as laboratory activities can not be entirely supplanted.

Bruner also suggested that action and perception could provide the basis for a symbolic representation that would be relatively general and applicable to a wide range of situations in addition to the ones initially encoded. Bruner makes no mention of concrete and formal; in his applications of this instructional method, concrete and formal are irrelevant concepts. Instead, Bruner takes care that the required actions and perceptions are simple and performed by the learners, and the symbolic representation falls within the scope of the language ability of the learner. Whether either constraint is met can be gauged only on the basis of experience with the learners. Bruner also pointed out that each culture transmits to its youth a set of intellectual tools which may be in part unique to the culture. The young follow the lead of their elders in acquiring those intellectual skills which are in current and frequent use. This is reminiscent of Dewey's (1910) claim that the division between concrete and abstract ideas depends on familiarity. Those ideas frequently encountered are called concrete while the uncommon ideas stike one as abstract. Dewey points out that familiarization with idea will transform one's reactio to them from a feeling that they are abstract to a feeling that they are concrete. The educational implication is that, wherever possible, try to make the use of basic intellectual skills part of students'everyday experience.

Ausubel, has taken issue with Piaget on the role of language. Ausubel believes in the possibility of meaningful verbal learning, while Piagetians apparently do not because it involves coercion and robs the student of the full opportunity for self-discovery. Ausubel's principal theoretical constructs owe much to Piaget. For example, Ausubel writes that "The most important single factor influencing learning is what the learner already knows" (1968). But Piaget wrote that "assimilation is the fundamental fact of psychic development" (1963), that learning should "vary very significantly as a function of the initial cognitive levels of the children" (1970). Ausubel anticipated Piaget when he stated that an individual might be formal in one fiels, concrete in another: "abstract thinking, for example, generally emerges earlier in science than in social studies because children have more experience manipulating ideas about mass, time, and space than about government." (1964). This is also Dewey's position. Ausubel goes on to point out that in some children depending on their special abilities and experience, the reverse may be true. Piaget intended precisely this meaning when he stated that although all normal subjects attain the stage of formal operations one can expect that they reach this stage in different areas according to their aptitudes and their professional specializations.

With above state of affairs in the field of scientific thinking skills research in education, it is becoming increasingly important for science educators and practicing teachers to know more about what they do and be able to analyze the cognitive weaknesses of the students in oreder to develop effective teaching strategies to help him. It is with this theoretical framework that this research proposed to study with some detail the inherent problems confronting the student in understanding scientific principles, concepts or laws, and using such knowledge in a wide variety of formal reasoning skills. The study was directed to the needs of the teacher, to analyze a number of factors that appear to impede the development of efficient teaching and learning conditions with special consideration to the development of logical thinking skills. Knowledge of a student's level of cognitive development would be useful for both planning a suitable course of study and for selecting teaching strategies matched to his ability level. The more information educators have about learners and the learning process, the better will be their chances of designing curricula and teaching strategies tailored to the needs of the learners. Until recently, assessment of the development of logical thinking abilities of students has been limited to educational researchers. This was true because of the time consuming process of conducting clinical interviews in order to assess the subject's levelof cognitive thinking. With the development of paper and pencil tests of logical thinking, it is now possible to get a measure of students' cognitive development level in a relatively short time. The theoretical framework of this research centered around the effect of various variables related to the growth of reasoning skills of learners.

As background of this research, the reasearchers would like to state that cognitive psychology is a branch of study wherein investigations of thought processes are conducted. The work of Piaget, a Swiss psychologist and epistemologist, figures largely in the area of human cognitive development as were discussed earlier. His studies of responses of young people of various ages to various tasks have allowed him to idntify various reasoning patterns. He proposed a theory of development which includes the concept of stages of intellectual development. The stages are characterized by distinctive features of a person's reasoning patterns. According to the theory, all persons progress through four stages in the same order though not necessarily in the same rate. The first two stages, sensory-motor and preoperational, are usually completed before a child is 7 or 8 years old as stated earlier. The last two stages are the concrete and formalstages and have been used as the major stages in this present research. It has been postulated by the researchers that students during their formal stages could perform tasks involving logical thinking skills such as conservation, proportion, controlling variables, probability, correlation, and combinatorial reasoning. However, the acquisition of the learners of the logical thinking skills as a part of the cognitive domain is known to be affected by various factors such as those derived from out-of-school experiences and in-school experiences related to science and other subject areas. The experiences of the learner could affect directly or indirectly the acquisition of reasoning thinking skills necessary in understanding various science lessons in school. Because the influence of formal thinking abilities on the development of logical thinking skills or the entire cognitive development of the student on his academic achievement is still not fully understood, this research has been designed to determine the nature and processes of the thinking abilities of the learners at the secondary school levels in Japan, Republic of Korea, United States, and the Philippines. It was hoped that this research would be able to answer a number of problems currently facing the teaching of science subjects in schools specifically to the adolescent students. The research intended to unveil the effects of the above listed variables on the overall cognitive development of the students, passing through teaching and learning experiences in precollege school science, in terms of their abilities not only to reason through a given problem situation, but also to transfer the knowledge of skills and processes to the other domains. The out-of-school experiences related to science as input in the educational process could directly affect or are correlated to the cognitive development of the learners as the output. The acquisition of reasoning and process skills could also be postulated to be affected by the psychomotor and the affective domains of learning.

Schools in all countries today may have various purposes such as the transmission of knowledge, skills, norms, and values. It can also be stated that schools nowadays attempt to develop on the learners the capability to think as they acquire their education. As a part of the educational process during the precollege school years, the exposure of the learners to activities related to the development of their reasoning thinking skills has become predominant as a result of utilizing the scientific method in science classroom activities. Cognitive development appears to result from a combination of the learners's biological development and his efforts to make sense out of experience. While the school can do little about biological development, it can stimulate cognitive development by providing opportunities for operative as well as figurative learning. The ability to learn figuratively seems to be present early in infancy. The development of operative capability appears to progress through a series of stages, increasing roughly with age up to a level that varies from person to person and is not completed until the late adolescence, if at all. It has been theorized that the logical thinking skills could be achieved by the learners when they are at the formal operational stage. So science education factors such as emotion, motivation, attitude, and experiences could be contributory to the fact that not all adolescents have begun to develop formal abilities.

B. OBJECTIVES OF THE STUDY

This study was conducted primarily to determine the commonalities in cognitive skills and other related factors in science education of some secondary school students in four countries namely, Japan, Republic of Korea, United States, and the Philippines. In addition to the baseline data gathered in this study about the cognitive skills at the secondary school level, it was also envisioned through this study to determined the cognitive skills of some elementary school learners, the effect of a laboratory-centered inquiry process in a science classroom, and teh implications of science teaching content appropriateness towards curricular revision with the aim of improving science instruction.

Specifically, the study dealt on the following aspects:

1. The comparison of the cognitive skills of the students in four countries on the basis of selected factors related to science education.

2. The effect and correlation on the cognitive skills possessed by the secondary school students of factors such as out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons.

3. The correlation and effect on the cognitive skills possessed by the elementary school pupils of factors such as out-

of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons.

4. The effects of a laboratory-centered inquiry process on laboratory skills, science process skills, and understanding of science knowledge of middle grade students.

5. The implications of science teaching content appropriateness towards science curricular revision.

The researchers embarked on this related to cognitive skills of the learners in order to test the folowing hypotheses:

a. there are commonalities in the cognitive skills possessed by the students from Japan, Republic of Korea, Philippines, and the United States;

b. a significant relationship exists between the cognitive skills and the factors such as out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons of the learners;

c. a significant positive correlation exists between the cognitive skills and the factors such as out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons;

d. a significant relationship exists between the laboratory-centered inquiry process and laboratory skills, science process skills, and understanding of science knowledge;

e. the content of the present science curriculum matches with the cognitive levels of the learners.

Hypotheses a and b, as stated above, have been tested using the data taken from the secondary school students in Japan, Republic of Korea, Philippines, and the United States, and from the elementary schools in Japan. The level of significance of the hypotheses were tested at .05 .

The different data coming from the four countries were independently analyzed using the hyptheses mentioned above in order to understand the commonality among countries.

C. SCOPE, SEQUENCE, AND DELIMINATION OF THE RESEARCH

This study was undertaken in order to analyze the effect of several variables on the cognitive skills possessed by secondary school students in Japan, Republic of Korea, Philippines, and the United States by means of looking at the intended, implemented, and attained curricula as shown in Figure 1. It could be noted from the flowchart presented that the interaction taking place in the classroom is commonly consist of the communication of the learners and the teachers with the aid of various media. However, this interaction could be bringing about a lot of learning outcomes that can be interpreted to foster the acquisition of skills that could be classified to be a part of the attained curriculum, or the output of the teaching-learning process. In order to foster the development of a classroom condition that could enhance the development of the various skills that the learners acquire in the classroom, it would be important for the teachers to know about the different factors such as the socio-cultural, personal, and school education

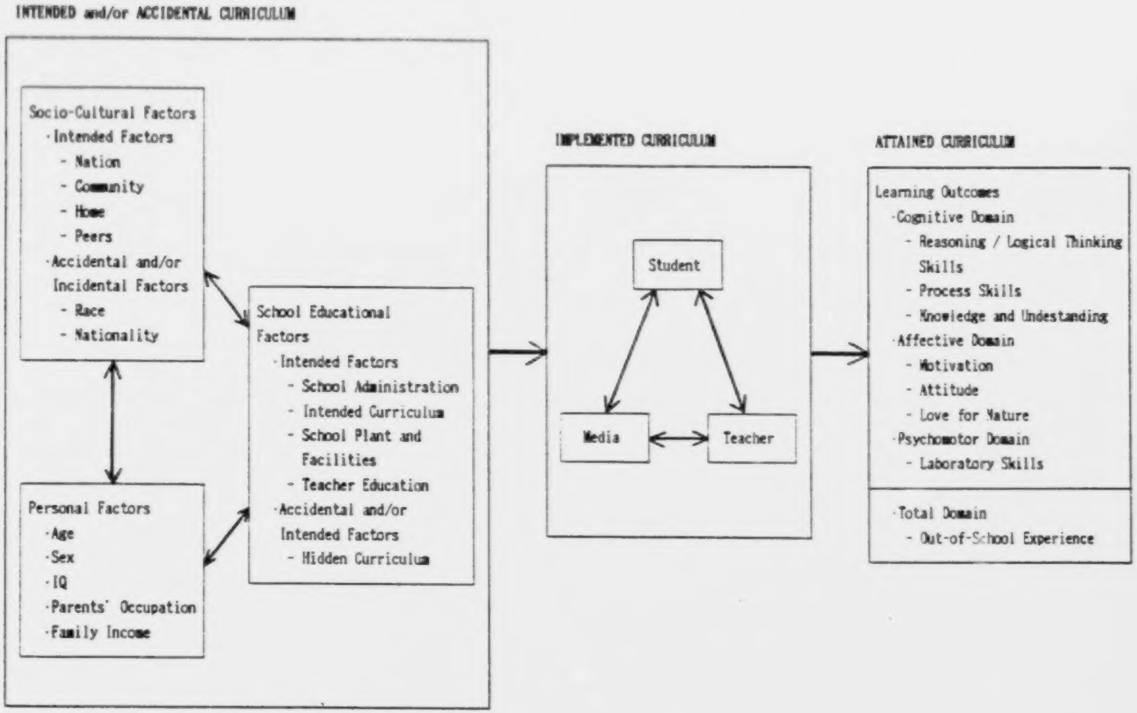
INTENDED and/or ACCIDENTAL CURRICULUM
Socio-Cultural Factors
·Intended Factors
- Nation
- Community
- Home
- Peers
·Accidental and/or Incidental Factors
- Race
- Nationality
Personal Factors
·Age
·Sex
·IQ
·Parents' Occupation
·Family Income
School Educational Factors
·Intended Factors
- School Administration
- Intended Curriculum
- School Plant and Facilities
- Teacher Education
·Accidental and/or Intended Factors
- Hidden Curriculum
IMPLEMENTED CURRICULUM
Student
Media
Teacher
ATTAINED CURRICULUM
Learning Outcomes
·Cognitive Domain
- Reasoning / Logical Thinking Skills
- Process Skills
- Knowledge and Undestanding
·Affective Domain
- Motivation
- Attitude
- Love for Nature
·Psychomotor Domain
- Laboratory Skills
·Total Domain
- Out-of-School Experience

FIGURE 1

SYSTEM ANALYSIS OF CURRICULUM AND INSTRUCTION IN SCIENCE EDUCATION factors.

As has been presented in Figure 1, the different socio-cultural factors included both the intended as well as the incidintal ones. The intended factors included the nation, community, home, and the peers of the learners. Undoubtedly, the incidental factors included the race and nationality of the learners. The personal factors specifically included the age, intelligence quotient, occupation of parents, and the family income. The school educational factors have been presented to include the administration of the school, school curriculum, school plant and facilities, and the preparation of teachers. It could also be stressed that the existence of the hidden curriculum can also strongly affect the acquition of knowledge and skills of the learners.

As has been presented in Figure 1, the different outcomes of the teaching-learning process that could take place in the classroom could bring about effects on the skills acquired by the learners in the cognitive, affective, and psychomotor domains of education. The cognitive domain included aspects such as in reasoning skills, process skills, and knowledge and understanding acquired by the learners. The affective domain incorporated the aspects on motivation, attitude, and love for nature. The laboratory skills can be classified to be a part of the psychomotor domain.

The out-of-school experiences of the learners in the various areas of studies could also be interpreted to have a direct effect on the attainment of the objectives of a given curriculum.

Although these activities are not commonly done within the school premises as a part of the regular school curriculum, their influence toward the learning process could not be dispensed with.

In this study, therefore, the outcomes of the teaching process as exiimplified in the performance of the learners on various cognitive, affective, and psychomotor evaluative instruments has been examined. The out-of-school experiences of the learners were also determined.

Knowing the wide scope being covered by the various factors that could influence the teaching-learning process taking place in the school, the sequence of the activities that are related to the study has been presented in the following diagram. It could be noted from the diagram that the school curriculum effectiveness requires the proper interrelatedness of the three phases shown in diagram which included learning outcomes, teacher, and the total system. The total system refers to the three phases of curriculum, namely, intended, implemented, and attained that were presented in Figure 1. The sequence of the activities related to this study included aspects which start from the knowledge construction, fragmentation and accumulation of knowledge, unification of knowledge, identification of more specific variables, reorganization, conceptualization and theory development, decision making, and policy making. In this report, the learning outcomes phase of the sequence has been investigated on by the researchers.

The content of the study presented in this report therefore

TABLE 1

DIAGRAM SHOWING SEQUENCE OF THE TOTAL EDUCATIONAL RESEARCH PHASES

Knowledge Construction	Acquisition of Fragmental Knowledge	Unification of Knowledge	Application of Knowledge	Reorganization of Knowledge	Conceptualization & Theory Development	Decision Making & Value Judgement
Factors Related to Research in Education	·Measurement of Learning Outcomes ·Measurement of the Effect of Instruction on the Learning Outcomes	·Identification of Commonalities and Differences	·Globalization of Education Based on the Commonalities ·Reevaluation of the Uniqueness of National Identity	·Need Assessment of Socio-Cultural, Personal, and School Education Factors	·Determination of the Interrelationships among Intended, Implemented, and Attained Curricula as Total System	·Recommendations ·Policy Making ·Implementation
Phase	Analysis I →	Synthesis I →	Evaluation I →	Analysis II →	Synthesis II →	Evaluation II
	Data Gathering and Analyses →			Hypotheses Building		

included the measurement of the learning outcomes in the field of science education in Japan, Republic of Korea, Philippines, and the United States. The commonalities among the countries with regard to the survey undertaken on the correlation and effect on the reasoning and process skills in science of variables such as the out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons using samples from the secondary school levels have been identified in the present study. Some elementary school pupils were also assessed on the basis of the aforementioned categories. A measurement of the effects of instruction on the learners has also been undertaken. In relation with these, the content of a science curriculum has also been assessed as to its relevancy to the cognitive levels of the learners.

METHODOLOGY OF RESEARCH USED

The descriptive-normative research method has been employed in this study. As a science education research, the study can be described as within the empirical and developmental types of research. The gathering of data has been undertaken using secondary school students in Japan, Republic of Korea, Philippines and the United States. In some of the sections, the data were also taken from among the elementary school pupils in Japan and the middle school pupils in the United States.

The map showing the geographical location of the secondary schools in the four countries involved in this study has been presented in Figure 2. It could be noted from the data that the secondary school students who were selected as samples in Japan

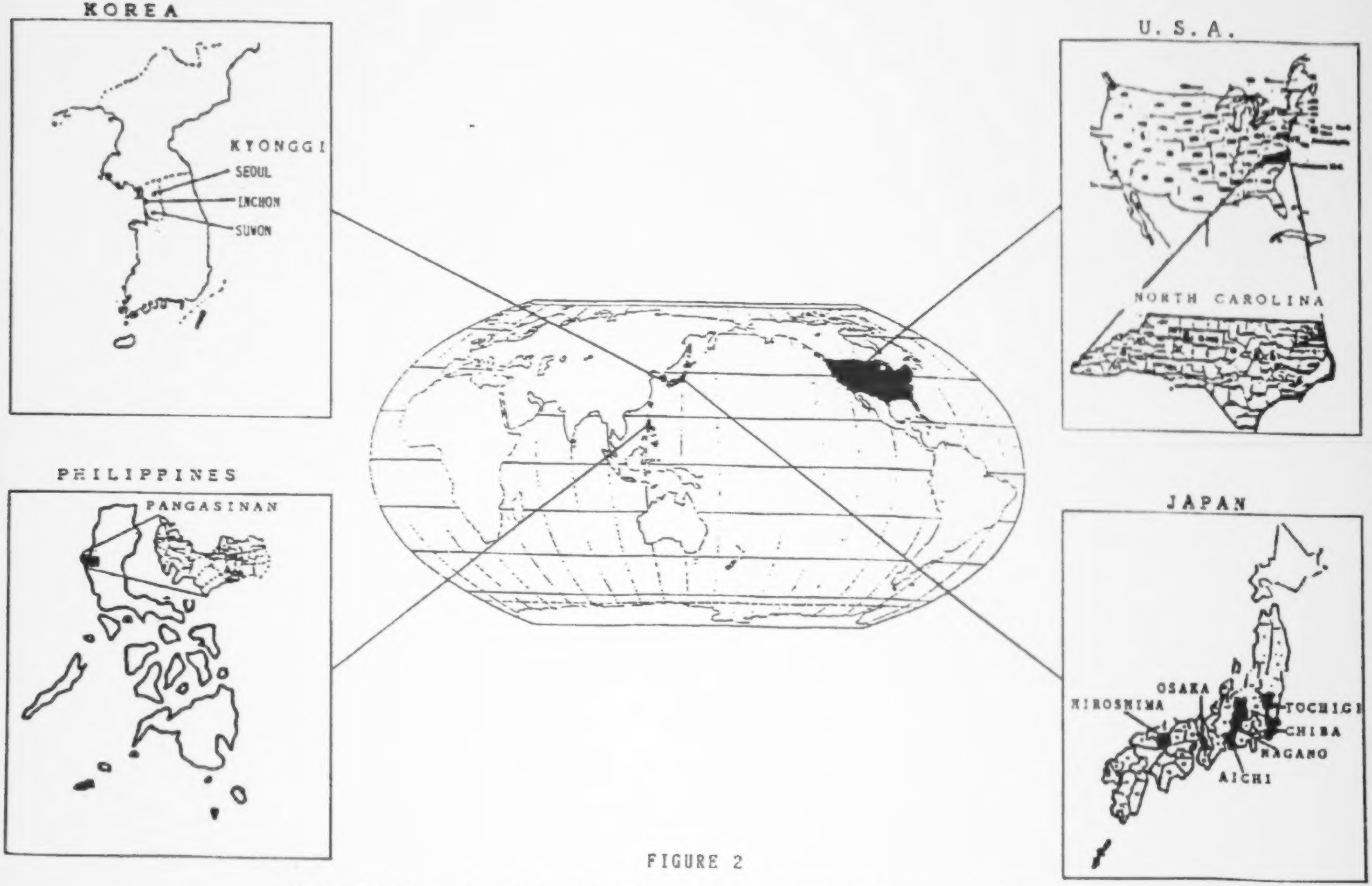
KOREA
KYONGGI
SEOUL
INCHON
SUWON
U. S. A.
NORTH CAROLINA
PHILIPPINES
PANGASINAN
JAPAN
OSAKA
HIROSHIMA
TOCHIGI
CHIBA
NAGANO
AICHI

FIGURE 2

MAP SHOWING THE SAMPLING AREAS OF THE STUDY IN FOUR COUNTRIES came from the prefectures of Aichi, Nagano, Chiba, Tochigi, Hiroshima, and Osaka. The samples from the Republic of Korea came from 3 major areas, namely: Metropolitan Seoul, Kyongki Prefecture, and Inchon City. The samples selected in the Philippines were those enrolled in the secondary schools in the Pangasinan Province. The sampling places in the United States were confined in the State of North Carolina.

The gathering of data has been undertaken in the four countries within a period of four years. The sampling and administration of the instruments period in each country have been made in different schedules with the exception of the data taken from the United States and Japan. The data in Japan and the United States were gathered during the school year 1984-1985. In the Philippines, the different instruments were administered to the students during the school year 1985-1986. The administration of the research instruments in the Republic of Korea was undetaken during the school year 1987-1988.

The different instruments used in the study which measured the reasoning skills and the science process skills as well as the student characteristics were administered in the different schools after the necessary permissions were provided by the school officials concerned in each of the 4 countries. The samples that were utilized from each country consisted of 4397 in Japan, 2497 in Republic of Korea, 1625 in the Philippines, and 3291 in the United States. The subjects from Japan consisted of 2285 males and 2112 females. The number of students from Japan has the following distribution: 1439 for Grade 7, 1479 for Grade

8, and 1479 for Grade 9. The distribution of the students from the Republic of Korea consisted of 1262 males and 1235 females. The number of students from the same country consisted of 817 Grade 7, 824 Grade 8, and 856 Grade 8. The total number of students from the United States can be broken down into 1603 males and 1688 females if the bases were sex, and 956 Grade 7, 1358 Grade 8, and 977 Grade 9 if the classification were to be made by grade level. The samples involved in the study in the Philippines included 398 Grade 7, 417 Grade 8, 417 Grade 9, and 393 Grade 10 students. The total number of pupils from the Philippines could be categorized by sex and as such the sample consisted of 665 males and 960 females. The samples from the different countries used in the study came from the various secondary school levels in the 4 countries.

The elementary school pupils in Japan that were used as sample of the study consisted of 1050 males and 1038 females. The pupils can be classified too according to grade level. Using this classification, the group consisted of 1046 Grade 5 pupils and 1042 Grade 6 pupils.

The middle grade pupils in the United States who were used as subject of the study comprized of 1402. Out of this number, 252 were in Grade 6, 834 were in Grade 7, and 316 were in Grade 8. These pupils were all selected in the State of North Carolina. They were used as samples for the validation of the Performance of Process Sills (POPS) Test.

In the section related to the effects of a laboratory centered inquiry program on laboratory skills, science process skills, and understanding of science knowledge in middle grade pupils a total of 226 pupils, with a breakdown of 85 Grade 6 and 141 Grade 7 pupils.

In order to gather the data about the cognitive skills and the student characteristics variables of the secondary school students in the 4 countries involved in the study, the following instruments were used: Group Assessment of Logical Thinking (AGLT), Test of Integrated Process Skills (TIPS II), Out-of-School Science Experiences Opinionnaire, Motivation Towards Science Processes Oppinionnaire, Love for Nature Opinionnaire, and Attitude Towards Science Lessons Opinionnaire. These instruments were translated into Japanese and Korean. The Japanese version were utilized in the different schools in Japan, and in like manner, the Korean version were used in Republic of Korea. The original English version of the different instruments were used to gather the data in the Philippines and the United States. However, the validation of these instruments has been made in all the countries prior to their actual utilization.

The instruments that were administered to the elementary school pupils in Japan for the purpose of assessing the cognitive skills as well as the pupil characteristics that they possessed included the following: a) Revised Group Assessment of Logical Thinking, b) Performance of Process Skills (POPS) Test, c)Out-of-School Science Experiences Opinionnaire, d) Motivation Towards Science Processes Opinionnaire, e) Love for Nature Opinionnaire, and f) Attitude Towards Science Lessons Opinionnaire.

The section on the effects of a laboratory-centered inquiry program on laboratory skills, science process skills, and understanding of science knowledge in middle grades students made use of the following instruments: Performance of Process Skills (POPS) Test, Middle Grades Integrated Science Process Skills Test, FIN Test, Laboratory Skills Test (LST), and California Achievement Test.

The reliability of the instruments that were administered in Japan, Republic of Korea, Philippines and the United States in order to gather the cognitive skills and the student characteristics were calculated using the Cronback Alpha. It has been found out that the Group Assessment of Logical Thinking Skills (GALT), which measured the reasoning skills, acquired a reliability of .73 in Japan, .61 in Republic of Korea, .77 in the United States, and .37 in the Philippines. The Test of Integrated Process Skills in Science (TIPS II) possessed the reliability of .86 in Japan, .79 in Republic of Korea, .82 in the United States, and .64 in the Philippines. In the same manner, the reliability of .87 in Japan, .87 in Republic of Korea, .91 in the United States, and .89 in the Philippines has been acquired by the Out-of-School Science Experiences Opinionnaire. The Motivation Toward Science Processes Opinionnaire garnered reliability ratings which were .91 in Japan, .89 in Republic of Korea, and .83 in the Philippines. The Love for Nature Opinionaire acquired a reliability of .83 in Japan, .80 in Republic of Korea, and .69 in the Philippines. Lastly, the Attitude Towards Science Opinionnaire eximplified the reliability of .94 in Japan, .90 in Republic of Korea, .95 in the

United States, and .83 in the Philippines.

The gathering of the data with regards to the cognitive skills of the learners in the four countries needed involved scheduling class periods for each class of students to take the various instruments. The guidelines followed in the administration of the instruments included the following: 1)the GALT and TIPS II test should be administered on two separate class sessions if feasible, 2) the GALT and the opinionnaire should be given during a fifty-minute class period, and the TIPS II and the attitude opinionnaire should be given during a second class period if feasible, 3) the teachers would serve as proctors, 4) the teachers would give the instruments to all sections of their science classes, 5) identification numbers would be assigned to all students and put on the instruments instead of names, and 6) answer sheets and questionnaires should be returned to the assigned coordinators and teachers. After the answer sheets were collected from the different schools involved in the study, the responses of the students were entered into the computer, HITAC M-200H(16MB main memory) of the Information Processing Center of Hiroshima University. The responses of the teachers were also processed in the same computer system. The Statistical Analysis System (SAS) program was used for descriptive statistics and hypothesis testing.

The statistical calculations made use of various procedures. At the beginning, the mean, standard deviations, variance, and standard errors of all the items in the instrument used were calculated based from the raw data that were used as input in the

HITAC computer. The cognitive developmental level of the different students were measured using the number of correct responses they have garnered out of the 12 items of GALT test. The classification were as follows: 0-4 points designated concrete stage, 5-7 designated transitional stage, and 8-12 designated formal stage. Graphs and figures were also made using frequency counts and percentages. Frequency block charts of the answers and reasons provided by the students in GALT and TIPS questions were also produced. Research hypotheses on the relationshops between factors and significant differences between factors were tested using the Statistical Analysis System (SAS) procedure. This method provided the Pearson Product Moment correlation coefficients and levels of significance. It has also been made the possibility to make computations of the Analysis of Variance (ANOVA) and Multivariate Analysis of Variance of the reasoning skills of students according to the classifications within each of the variables or factors used in this study. The computation of the t-test values was also made in some cases.

The section on the effects of a laboratory-centered inquiry program on laboratory skills, science process skills, and understanding of science knowledge in middle grades students made use of the Multivariate Analysis of Covariance (MANCOVA) in order to examine the effects of FAST treatment. The Univariate Analysis of Covariance (ANCOVA) to examine the effects of FAST treatment on each dependent variable with covariate CAT was conducted in each grade level.

Chapter II

DEVELOPMENT OF RESEARCH INSTRUMENTS

The research study made use of instruments purposely designed to measure the scientific thinking skills possessed by learners at the elementary and secondary school levels. These instruments are Group Assessment of Logical Thinking Skills (GALT), Test of Integrated Process Skills (TIPS), and Performance of Process Skills (POPS) Test.

Other instruments such as the questionnaires on Science Related Experiences, Attitude Towards Science, Motivation Towards Science, and Emotion Towards Science were also included for the purpose of assessing the other cognitive, affective, and psychomotor facets possessed by the subjects of the research study.

The laboratory-centered inquiry program has been assessed on its effects on laboratory skills, science process skills, and understanding of science knowledge of some learners by using instruments such as the Laboratory Skills Test (LST), California Achievement Test (CAT), and the Performance of Process Skills (POPS) Test.

A. The Group Assessment of Logical Thinking (GALT)

The Group Assessment of Logical Thinking (GALT) has been designed by Roadrangka, Yeany, and Padilla in cooperation with other researchers on logical thinking skills. The test was revised in 1983 into a twelve-item test that could be divided into six subscales involving data from 2 test items. The correlation between test scores from the original test and the shortened test was very high, so it was decided to use the short version. The test measures six logical thinking skills, namely: conservation (items 1 and 2), proportional reasoning (items 3 and 4), controlling variables (items 5 and 6), probabilistic reasoning (items 7 and 8), correlational reasoning (items 9 and 10), and combinatorial reasoning (items 11 and 12).

The GALT test used a double multiple choice format for presenting option for answers as well as the justification or reason for that answer. It also used pictorial representation of real objects in all test items and so it could be used for students enrolled at the sixth grade level or higher in the elementary school. The test used in Japan was translated into Japanese and was validated for use at the lower secondary school level. The test was also translated into the Korean language so that Korean students could also use it. The GALT test that was used in the Philippines was written in English as in the original one except the changes that have been made on some terms which were thought to be difficult for the Filipino students to understand due to cultural reasons. The original English GALT test was administered in the United States. The GALT test has another advantage because it can be administered in one class period to a large group of individuals under the supervision of just a few proctors.

The test items that had been employed in previous researches were used as a basis for developing GALT. The majority of test items came from Lawson's Classroom Test of Formal Operation (1978). Others came from Burney (1974), Ankney and Joyce (1974), and Longeot (1968). The justification for basing the test on items from previous instruments was that these items possess a high reliability and validity and each item measured one of the formal reasoning abilities. Each question which was selected presented an experiment or a problem. The student was asked to select the best answer to each problem from among four or five options and usually required a written justification for choosing that answer. The GALT can be supported as a reliable and valid instrument to measure formal reasoning skills. The efficiency and convenience of use through paper and pencil administrations with no need for individual interview or demonstration is backed up with a very adequate reliability of 0.85. All the items appear to be functioning to descriminate among the various levels of formal reasoning ability. The validity of GALT is supported by the strong correlation of 0.80 between the classification of an individual through the use of GALT and the interview results. the construct validity of the measure can be argued for on the basis of the single factor solution of the correlated sub-teats and the ability on predicting process skill achievement. More than fifty percent of the variance in process skill ability can be predicted on the basis of GALT scores.

The GALT test has been selected to be used in measuring the logical thinking skills of students because it can provide a measure for the researcher to assess the cognitive development of a large number of students within a single class period. The results can be used by teachers to better understand the abilities of the selected students in Japan, South Korea, United States, and the Philippines and to match instructions and materials accordingly. The results can be used to measure the entry level characteristics of students and examine potential interactions with other factors related to science education in schools. In addition, the influence of a science curriculum on the development of the skills measured by GALT can be easily evaluated due to the fact that the test has not been used so much yet in the four countries.

B. The Test of Integrated Process Skills (TIPS II)

The Test of Integrated Process Skills (TIPS II) that was used in this study was designed by Burns, Wise, and Okey. It was designed to assess the process skills that the students possess. It is a valid and reliable science process skills test for students enrolled at the secondary level. The instrument contains multiple-choice items which were derived for each of the following five objectives, namely: 1) identifying variables, 2) identifying and stating hypothesis, 3) operationally defining, 4) designing investigations, and 5) graphing and interpreting data. The instrument consisted of 36 items designed to measure the aforementioned process skills which are considered to be necessary for secondary school students for their success in a science classroom setting and also to provide them tools for the class.

The 36-item test can be completed within a normal class period, or a typical student can take it from 25 to 50 minutes. There is a mean difficulty and discrimination indices of 0.53 and 0.35 and so the results yielded a mean score of 19.14 and a total test reliability of 0.86 during the validation process. The test provided another reliable instrument for evaluating the competence of students in the integrated science process skills because it is not specific to a given curriculum or content area, so it can be used across the various disciplines of science. It was also deemed important by the researchers to state the reasons for selecting TIPS II to be used in the present research study. The science process skills became predominant in the classroom with the advent of several of the activity and inquiry-oriented curriculum projects such as BSCS, SCIS, ISCS, and SAPA. Dillashaw and Okey (1980) provided an overview of process skills test development during the 1960's and the 1970's. However, these activities were directed to specific curriculum projects. In the case of SAPA various process tests were constructed by educators such as Walbesser (1965), McLeod et. al. (1975), and Ludeman (1975). In 1972, Riley developed another process test based on the SCIS curriculum project. Other tests developed by Molitar and George (1976) and Tannenbaum (1968) were not specific to a certain curriculum, but were directed towards upper elementary and lower secondary school students, respectively. And so in 1980, in response to the pressing need for a process skills test for secondary school students that are not specifically directed to any curriculum project, the Test of Integrated Process Skills (TIPS) was jointly developed by Dillashaw and Okey. In a review of evaluation instruments in science, Mayer and Richmond (1982) noted the increase in process-oriented tests since 1960's, particularly at the elementary and lower secondary school levels. In view of the continued need and relative scarcity of process skills teat for secondary school students, the present development of TIPS II took place. The new item could serve either as an alternate or equivalent process skills test or add to the pool of items available for diagnostic and summative testing in science classes or research studies like this present study.

C. Performance of Process Skills Test (POPS)

The Performance of Process Skills Test (POPS) was developed by Pottenger, Mattheis, Jones, and Nakayama (1987) to answer the need for a valid and reliable noncurriculum-specific measure of integrated science process skills that can be used with middle school students.

At the middle school level, integrated science process skills such as identifying experimental questions, identifying variables, formulating hypotheses, designing investigations, graphing and interpreting data are a vital aspect of meaningful science laboratory activity. These process skills represent the rational and logical thinking skills required in the process of problem solving in science. Few paper and pencil instruments to assess the process skills performance for middle grades students exist; thus, the development of the present POPS test took place.

The POPS test is a refinement and modification of the set of process skill objectives and test items assessed by other existing integrated science process skills test, one of which is the Middle Grades Integrated Science Process Skills Test (MIPT) by Cronin and Padilla (1986). The MIPT test consists of 40 items designed to assess seven integrated process skills in science, They are identifying research questions (6 items), stating hypotheses (6 items), identifying variables (8 items), designing investigations (6 items), constructing data tables (4 items), constructing graphs from data (4 items), and drawing conclusions (6 items). These MIPT items were in turn selected from a pool of test items, such as the Test of Integrated Process Skills by Dillashaw and Okey (1980), the Group Test of Integrated Process Skills by Tobin and Capie (1982), and the Test of Graphing in Science by Mckenzie and Padilla (1986), and modified for use with middle school students, including new items.

Six process skill objectives had been identified and used as basis for the POPS items. These were identifying experimental questions (3 items), identifying variables (6 items), formulating hypotheses (3 items), designing investigations (3 items), graphing data (3 items), and interpreting data (3 items). These objectives had been reviewed and found to be valid representations of the intended process skills. The process skill objective, constructing data tables, in the HIPT was eliminated.

The POPS test consists of 21 items, each of which had been carefully analyzed to ensure that it measured the appropriate skills and not specific knowledge in a particular procedure or science content. All are multiple choice items with four alternatives each item.

The items had been content validated by four science educators with experience in both test construction and the integrated science process skills. All four reviewers were consistent in on almost all items in terms of indicating the correct answer and keying to a process skill objective. This concurrence had been taken as evidence of content validity and objectivity of scoring. Revisions had been made on items where modifications were suggested. Modifications included changes in wording and sentence length to provide additional explanation for specific terms, i.e., the manipulated variable or the condition which was changed, the responding variable or the condition which is the measured outcome of the experiment, and the controlled variable or the condition that was kept constant.

The readability of the POPS test was assessed using the FOG index (Gunning, 1975). This index predicts the reading grade level necessary to read with 90 to 100% comprehension. On this scale, POPS obtained an average grade level index of 6.8.

The reliability and item indices of the modified version of the POPS test had also been examined by administering it to middle school students in grades six through eight. A total of

1,402 students from a relatively rural school district in an eastern part of North Carolina had been involved in this field test. The sample group involved was heterogeneous to provide representation across ability levels, socio-economic levels, gender, and race.

The mean score and standard deviation for overall students on the 21-item test were 9.7 7 and 4.16 respectively. Toral scores ranged from 1 to 20 with a standard error of measurement of 2.08. Total test reliability, as computed by the Kuder-Richardson formula (KR-20) was 0.75. Item difficulty indices ranged from 0.28 to 0.79 with an average of 0.47. Item discrimination indices obtained using the upper 27% and lower 27% of the sample group ranged from 0.27 to 0.71 with an average of 0.49 and were above 0.30 for 20 of the 21 items. Point biserial correlation indices of item discrimination ranged from 0.28 to 0.55 with an average of 0.41 and were above 0.30 for 19 of the 21 items. Each of these three test characteristics (reliablity, item difficulty index, and item discrimination index) were well within the acceptable range for reliable tests (Payne, 1974). Based on these results from the field test, no further test revisions were considered necessary.

The descriptive statistics obtained by field tests indicated that mean performance on the POPS test was comparatively low (9.8 out of 21). The standard deviation of 4.2 and a range of 20 indicated that the test differentiated students of differing ability. This observation was supported by the indices of reliability, item difficulty, and item discrimination which provided measures of the suitability of the test scores for differentiating student performance. Since each of these indices fell well within the acceptable range for reliable tests, the POPS test can be used by teachers to obtain dependable student data as a basis for making decisions about individual students on item performance. In a research context, the test can be used to obtain measures to answer questions that require individual student performance to be differentiated or mean performance on the POPS items to be compared. The POPS measures are dependable for answering a range of research and evaluation questions where performance of students, performance on items, or performance on different occasions need to be differentiated. The POPS test has applications for research and evaluation where teaching and learning integrated science process skills are a concern, if it is a valid measure of this ability.

D. FIN Test

The FIN Test was developed by Fukouka, Pottenger, Ishikawa, and Nakayama (1987). It consists of six relatively general items designed to evaluate the understanding of basic science knowledge in the extended context of the Foundational Approaches in Science Teaching 1(FAST 1) program. They are as follows: existence of bouyancy, conservation of weight, direction of gravitational force, equilibrium of system (subsurface floating of object), water pressure as force, and density. The questions are answered by writing appropriate explanations on each item.

E. Laboratory Skills Test (LST)

The Laboratory Skills Test (LST) was developed by the Curriculum Research and Development Group in the University of Hawaii (1987). It consists of sixteen items divided into three parts which are relatively related to the Fast 1 context. LST Part 1 consists of six items designed to assess the pratical laboratory skills such as measuring height, area, mass, volume displacement, and calculation of density. LST Part 2 consists of six items designed to assess the process skills of graphing and interpreting data. LST Part 3 consists of four items designed to assess knowledge and understanding of the density concept. The questions are answered by writing the appropriate answer on each item.

F. California Achievement Test (CAT)

The California Achievement Test (CAT) itself was not available so the scores (national percentile of the CAT total battery) of individual students were gathered from each teacher in order to establish an equivalency between experimental and control groups.

G. Student Questionnaire on Out-of-School Science Experiences

The Student Questionnaire on Out-of-School Science Experiences aims to learn more about the various activities that the students participate in when out of the school premises. The students were asked to read through each of the 29 items

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"out-of-school activities" and then were allowed to indicate how frequently they have been involved with the different activities during the past two years using the following key: Never -- 1, Rare -- 2, Sometimes -- 3, Often -- 4, and Very Often -- 5. A copy of this instrument is shown in the succeeding page.

The content of the instrument designed to measure the amount of experiences the students had were made by the researchers after a thorough examonation of all the activities that the learners commonly do after their regular school activities. In order to eliminate the bias of the opinionnaire, the different activities were formed in such a way that both male and female groups could answer the items correctly regardless of thei gender. The respondents were also cautioned to limit only the inclusion of the experiences they have dealt with within the past two years. This time frame is supposedly just right for the respondents to easily recall most if not all their science-related experiences while out of their schools.

The final version of this opinionnaire was later validated by the same researchers by trying out on selected students in Japan and the United States.

Sample Opinionnaire 1

STUDENT OPINIONNAIRE OUT-OF-SCHOOL SCIENCE EXPERIENCES

The purpose of this questionnaire is to learn more about the various activities that students participate in when they are out of the school premises. Please try to respond each of the statements as fairly and quickly as possible. Thank you for assisting us in this important research.

Please read through each of the following "out-of-school" activities" and indicate how frequently you have been involved with them during the past two years using the following key:

1 = never 2 = rare 3 = sometimes

4 = often 5 = very often

Please indicate your answer by placing an X in the appropriate space in the answer sheet.

ACTIVITIES	FREQUENCY OF ACTIVITIES				
	1 Never	2 Rare	3 Some-times	4 Often	5 Very Often
1. Visits to science museums, science centers.............					
2. Visits to planetarium.......					
3. Visits to the libraries to read science books, magazines, periodicals, etc.					
4. Visits to marine science centers....................					
5. Visits to the zoo...........					
6. Visits to botanical gardens.					
7. Receives private tutoring in science and/or mathematics..					

8. Take part in camping, hiking or hiking.................. ____________________

9. Have an experience in watching birds.............. ____________________

10. Have an experience in collecting insects.......... ____________________

11. Have an experience in gathering plants............ ____________________

12. Have an experience in gathering rocks and fossils. ____________________

13. Observe stars and moon through telescope........... ____________________

14. Have an experience in building model ships, cars, airplanes, or dollhouse..... ____________________

15. Have an experience in reporting your findings to your friends................ ____________________

16. Take part in science fairs and contest................ ____________________

17. Visit geological places such as rock strata, volcanoes, seashores.................. ____________________

18. Take part in science club activiites.................. ____________________

19. Participate in special activities of science center or museum.................. ____________________

20. Participate in boy or girl scouting.................. ____________________

21. Watch TV science programs or listen to radio science programs.................... ____________________

22. Have experience in using microscopes................ ____________________

23. Have experience in making scientific experiments with your own instruments........ ____________________

24. Have experience in using microcomputers.............. ____________________

25. Have experience in caring for birds, rabbits, cats, dogs, or hamsters........... ____________________

26. Have experience in caring for fish.................... ____________________

27. Have experience in examining and repairing electrical appliances.................. ____________________

28. Have experience in using woodwork or metal work tools e.g., pliers, saw, planes, screwdrivers, etc........... ____________________

29. Have experience in raising your favorite plants........ ____________________

H. The Degree of Motivation Towards Science Processes and Love for Nature Scale

The Science Process Degree of Motivation Towards Science Processes and Love for Nature Scale consists of a number of statements designed to sample the degree of motivation towards science processes and the degree of love for nature related to some aspects of science of the selected respondents of this study. The scale sought for the individual feeling of the respondents about the statements. The science processess section of the scales consisted of 15 items. The respondents were asked to encircle the response which to their mind best represents their opinion to the various statements using the following key: Not motivated at all -- 1, Fairly motivated -- 2, Undecided -- 3, Motivated -- 4, and Strongly motivated -- 5. The section on love for nature consisted of four items specifically on "Beauty of Nature", "Greatness of Nature", "Respect for Life", and "Love for Nature". The respondents were requested to encircle the response which best represents their degree of emotion using the following five-point scale: Do not feel it at all -- 1, Feeling it fairly -- 2, Undecided -- 3, Feeling it -- 4, Feeling it strongly -- 5. The scales used in the Degree of Motivation Towards Science Processes and Love for Nature follows the Likert Type of calibration. A sample of the scale is given in the next page.

Sample Opinnionaire 2

DEGREE OF MOTIVATION TOWARDS SCIENCE PROCESSES AND lOVE FOR NATURE

The scale consists of a number of statements designed to sample your degree of motivation towards science preocesses and and your love for nature related to some aspects of science. There are no right or wrong answers. What is wanted is your own individual feeling about the statements. Please read each statement carefully and decide how you feel about it.

Please use the answer sheet.

A. Motivation Towards Science Processes

Please encircle the response which best represents your opinion to the statements below in the following manner:

Not motivated at all 1
Fairly motivated 2
Undecided 3
Motivated 4
Strongly motivated 5

Science Processes Scale

1. Working patiently on an investigation until the time you can arrive at a solution............................... 1 2 3 4 5

2. Carrying out an investigation using only the available facts................ 1 2 3 4 5

3. Devising a new method of observing and experimenting...................... 1 2 3 4 5

4. Thinking logically and critically....... 1 2 3 4 5

5. Getting involved in data collection..... 1 2 3 4 5

6. Getting involved in finding problems from the environment.................... 1 2 3 4 5

7. Sorting and classifying natural objects. 1 2 3 4 5

8. Testing new ideas...................... 1 2 3 4 5

9. Predicting, hypothesising, inferring.... 1 2 3 4 5

10. Recording data......................... 1 2 3 4 5

11. Analyzing data......................... 1 2 3 4 5

12. Interpreting data...................... 1 2 3 4 5

13. Identifying regularities from data...... 1 2 3 4 5

14. Applying findings to new problems....... 1 2 3 4 5

15. Cooperating with other students......... 1 2 3 4 5

Love for Nature

Please encircle the response which best represents your love for nature to the statements given below in the following manner:

Do not feel it at all................ 1
Feeling it fairly.................... 2
Undecided............................ 3
Feeling it........................... 4
Feeling it strongly.................. 5

Love for Nature Scale

1. Beauty of nature....................... 1 2 3 4 5

2. Greatness of nature.................... 1 2 3 4 5

3. Respect for life....................... 1 2 3 4 5

4. Love for nature........................ 1 2 3 4 5

I. Science Attitude Scale

The Science Attitude Scale consisted of a number of statements designed to sample the opinions of the selected respondents about science. The scale asked the feelings of the respondents towards the statements. The scale was adapted by spooner from a scale developed by Lewis R. Akin to measure student attitudes towards the study of mathematics. It was therefore modified to reflect attitudes towards science instead of mathematics. The modified instrument has a very high reliability of 0.95 and so a decision was made to include it as one of the research tools in this study. A copy of the Science Attitude Scale is given in the next page.

The twenty-item scale was scored on a Likert Type with the use of the following symbols to represent the opinions of students, to wit: Strongly disagree -- SD, Disagree -- D, Undecided -- U, Agree -- A, Strongly Agree -- SA. The responses of the students were given numerical equivalents during the calculation and so "Strongly disagree" correspond to 1, "Disagree" correspond to 2, "Undecided" correspond to 3, "Agree" corresponded to 4, and "Strongly agree" correspond to 5.

Sample Opinionnaire 3

ATTITUDE TOWARDS SCIENCE LESSONS

The survey consists of a number of statements designed to sample your opinions about science. There are no right or wrong answers. What is wanted is your own individual feeling about the statements. Please read each statement carefully and decide how you feel about it.

Please encircle the response which best represents your opinion to the following statements in the following manner:

If you strongly disagree, circle "SD".... SD D U A SA
If you disagree, circle "D".............. SD D U A SA
If you are undecided or uncertain, circle "U" .... SD D U A SA
If you agree, circle "A" .... SD D U A SA
If you strongly agree, circle "SA" ...... SD D U A SA

Please use the answer sheet.

1. I am always under a terrible strain in a science class .... SD D U A SA
2. I do not like science and it scares me to have to take it .... SD D U A SA
3. Science is very interesting to me and I enjoy science courses .... SD D U A SA
4. Science is fascinating and fun .... SD D U A SA
5. Science makes me feel secure and, at the same time it is stimulating .... SD D U A SA
6. My mind goes blank and I am unable to think clearly when working in science ...... SD D U A SA
7. I feel a sense of insecurity when attempting science .... SD D U A SA
8. Science makes me feel uncomfortable, restless, irritable, and impatient .... SD D U A SA
9. The feeling that I have toward science is a good feeling .... SD D U A SA

10. Science makes me feel as though I am lost in a jungle of numbers and can not find my way out .... SD D U A SA

11. Science is something which I enjoy a great deal .... SD D U A SA

12. When I hear the word science, I have a feeling of dislike .... SD D U S SA

13. I approach science with a feeling of hesitation, resulting from a fear of not being able to do science .... SD D U S SA

14. I really like science .... SD D U S SA

15. Science is a course in school which I have always enjoyed studying .... SD D U S SA

16. It makes me nervous to even think about having to do a science experiment .... SD D U S SA

17. I have never liked science and it is my most dreaded subject .... SD D U S SA

18. I am happier in a science class than in any other class .... SD D U S SA

19. I feel at ease in science and I like it very much .... SD D U S SA

20. I feel a definite positive reaction to science; it is enjoyable .... SD D U S SA

Chapter III

THE SCIENTIFIC THINKING SKILLS OF SOME SECONDARY SCHOOL STUDENTS IN JAPAN, REPUBLIC OF SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES

It can be postulated that science classes in most countries nowadays experience the existence of teachers who, while doing their classroom tasks, could observe the spectacular variation in the ability of the learners to understand scientific ideas and the utilization of the scientific thinking skills that could include the reasoning and process skills in science. However, it could also be stated that students from one country to the other vary in the capability of the learners to deal with the reasoning skills such as conservation, proportion, control of variables, probability, correlation, and combination as a result of several interrelated factors that are sometimes difficult to point out. This fact also holds true in the case of the science process skills which included identifying variables, graphing and interpreting data, identifying and stating hypotheses, operationally defining, and designing investigations. As a result of this fact, teachers may observe in their science classes that some learners are highly capable and can show extremely developed reasoning techniques. On the other hand, some of the learners could be observed to be lacking the skill to form conceptualization images of whatever topics being discussed in class thereby causing them to experience difficulty in learning various science concepts being offered to them. The idea exists among educators that the acquisition and understanding of science lessons can be affected by the capability of the learners to deal with the different reasoning and process skills in science.

With certain kinds of educational experience, it can probably be stated that majority of the learners, if not all, can reach a level of scientific thinking skills that could give them much greater intellectual capability than they are supposed to acquire if they are not well provided with these valuable undertakings. With the development of reasoning skills, the learners at the secondary school level who are in their adolescent years could certainly be observed to be skillful at understanding inquiries and thereby making some speculations on cause-and-effect relationship concepts. The inquiry process related to the scientific thinking skills of the learners could be stated a necessary activity if educators would like to determine the capabilities of their students in these skills. It was stated by Roadrangka, Yeany, and Padilla (1983) that:

"....concepts matched to the developmental level of students are more easily learned. One way to try to facilitate this in science teaching is to match instruction and curriculum materials with the cognitive developement of the students. To do this, the assessment of developmental reasoning capabilities of the student is necessary. The result from the assessment can be used not only to modify science teaching strategies, but also to help teachers better understand the level of their students' intellectual development".

Based on the aforementioned statement, the assessment of the reasoning skills of some students in some secondary schools in Japan, Republic of Korea, United States, and the Philippines could therefore bring about the possibility of acquiring the knowledge on what developmental levels the students have and also the skills they could perform. The scientific thinking skills possessed by the samples taken from the countries presented in this study are therefore presented in this section.

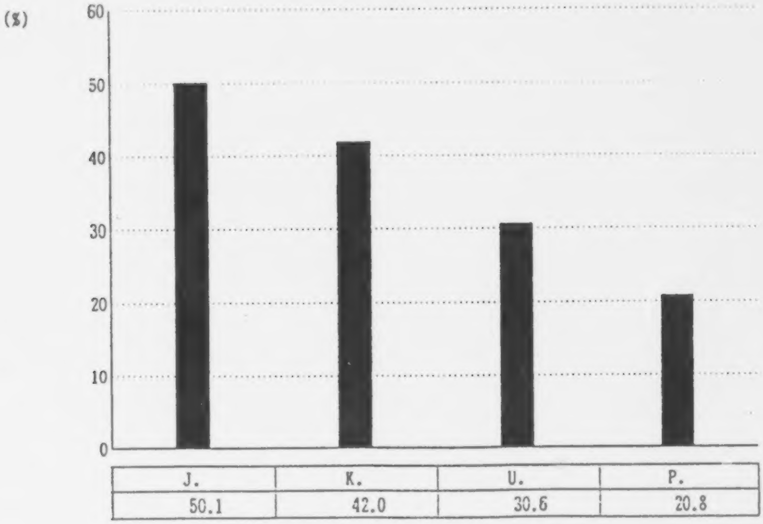
I. COGNITIVE SKILLS IN SCIENCE

A. Reasoning Skills Possessed by the Students

The different reasoning skills utilized in this study showed similarities as well as differences in results based on the number of students who correctly answered the skills, in a summarized form, in all the countries involved. It can be observed from the data gathered that there exist some commonalities among the countries in terms of sex and grade level based on their total score in all the measures of reasoning skills.

1. Total Reasoning Skills

The average percentage of the number of students who were able to correctly answer the different subscales of the measure of reasoning skills in each country was presented in Figure 3. It can be gleaned from the data that the students in Japan were able to acquire a percentage that is just a little bit higher

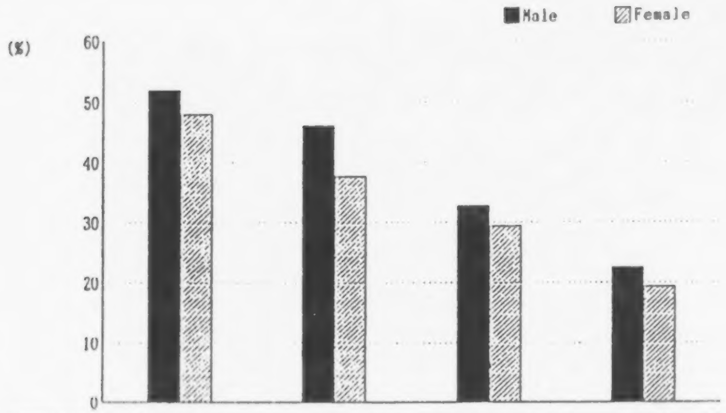


J.	K.	U.	P.
50.1	42.0	30.6	20.8

FIGURE 3

PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED GALT SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES than 50%, 50.1% to be specific. The samples selected in the present study, comprising of lower secondary school students, seemingly were not able to answer all the questions perfectly as can be observed from the data presented. The ascending order of the sample based on the countries they belong followed this pattern: Philippines, United States, Republic of Korea (also referred to as South Korea in this research report), and Japan. The data showed only the performance of the respondents in the present study, and therefore did not necessarily reflect the total school population of the countries involved since the samples were taken only from schools in selected areas as was explained in Chapter I. The comparison of the samples by country, therefore can be directed towards the analysis of the similarities and differences of samples by sex and grade levels of the students.

In Figure 4, the samples from the different countries seem to project a common trend. The occular inspection of the data suggest that the males seemed to have required an average percentage of those who were able to answer correctly the questions related to reasoning skills higher than the females. The data further depicted the fact that the differences on the average percentages between tha males and the females seem to be similar within the samples from all the countries except South Korea. The males and females in South Korea seemed to have a wider gap as presented by the average percentage of 46.1 and 37.8. This condition can probably explained by the fact that in South Korea, the students at the secondary school levels commonly

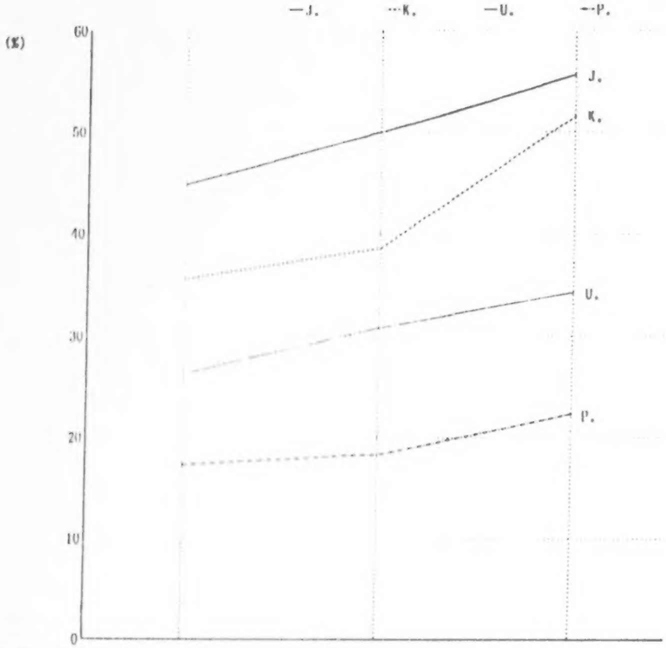


	J.	K.	U.	P.
Male	52.0	46.1	32.8	22.7
Female	48.1	37.8	29.5	19.5

FIGURE 4

PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED GALT SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY SEX go to schools that are not coeducational in nature. The students commonly go to their respective schools classified according to whether they are males or females. If the reasoning skills of the students were affected by the type of curricular offerings they have gone through, then a wider gap between the males and the females can be explained in this manner. However, in the case of the samples from Japan, United States, and the Philippines, a remarkable difference between the two sexes aould also be observed although the schools where the samples were taken are being administered using the coeducational system. The males were observed to have acquired a higher percentage average compared to the females whether the type of schooling is coeducational or not. Do males really perform better than the females in the reasoning skills assessed in this study? The data gathered seemed to have supported the males gaining an edge over the females in the reasoning skills asessed.

The similarities in the average percentages of students who were able to answer correctly the six subscales of the reasoning skills by country were presented in Figure 5. The data seemed to suggest that there is a remarkable progress in the students capability to deal with the reasoning skills as they move towards the higher grade level of the secondary school. The data on the United States and Japan seemed to project a regular increase on the average percentage of students who dealt correctly with the reasoning skills from grade seven to grade nine. However, the data from the Philippines and South Korea seemed to show a slight increase on the average percentage of students getting the



	7th	8th	9th
J.	44.8	49.9	55.6
K.	35.6	38.5	51.5
U.	26.4	30.8	34.3
P.	17.3	18.3	22.3

FIGURE 5

PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED GALT SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE LEVEL correct responses between grade eight and grade nine. This condition can probably be explained by the fact that maturation has an observable effect on the capability of the students to deal with the reasoning skills. It can however be stated too that the experiences of the learners as a result of their being exposed to the different reasoning skills during the performance of science activities and also in other classes such as in mathematics.

The differences of the average percentage of students who were able to answer correctly the different reasoning skills based on sex and grade level were also tested using the analysis of variance as shown in Table 2. The data depicted the fact that the female students acquired significantly lower average percentage. The lower grade pupils were also able to acquire significantly lower average percentage. The lower grade pupils were also able to acquire significantly lower average percentage compared to the upper grade pupils. The data in Table 2 suggested that all the countries possess significant differences on the percentage of students who were able to answer correctly the reasoning skills problems when categorized by sex and grade levels. The implication of this condition could be that the male students in the four countries experienced more activities that could improve their capability to deal with these types of problems as used in the study. Males could probably be genetically different when compared to the females with the ability to deal with the different reasoning skills such as conservation, proportional reasoning, controlling variables,

TABLE 2

CORRECT RESPONSES IN ALL GALT SUBSCALES IN PERCENT BY SEX AND GRADE LEVELS

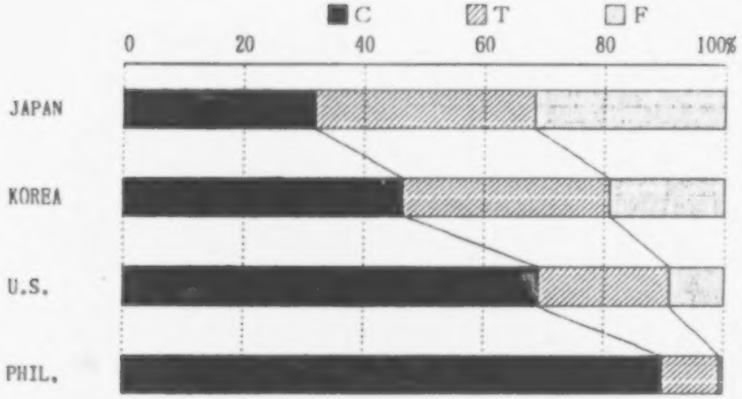
	JAPAN	KOREA	U.S.	PHILIPPINES
Total Group	50.1	42.0	30.6	20.8
Male	52.0	46.1	32.8	22.7
Female	48.1	37.8	29.5	19.5
Sex Difference (df=1)	F=35.98••	F=116.39••	F=19.19••	F=25.14••
7th	44.8	35.6	26.4	17.3
8th	49.9	38.5	30.8	18.3
9th	55.6	51.5	34.3	22.3
Grade Difference (df=2)	F=91.28••	F=163.69••	F=42.22••	F=34.86••

combinatorial reasoning, probabilistic reasoning, and correlational reasoning.

2. Developmental Levels of Students Based on GALT Total Score

The developmental levels of the secondary school students in Japan, South Korea, United States, and the Philippines were also calculated based on the results of the test on logical thinking skills. The categoroes of developmental levels included concrete, transitional, and formal level. The samples from the four countries theoretically are considered to be all within the fromal operation period if the basis is just the chronological age because according to Piaget, the formal operation period starts from 11 to 15 years of age and onwards. Since the students can be classified as in formal operation level theoretically, the research result as shown in Figure 6 showed a data that run counter against the theory as based by Piaget based on his many experiments on logical or reasoning skills. It could also be stated, however, that the idea of Piaget on the existence of stages or period of cognitive development could actually be analyzed in view of the conditions of probability. At a given age, there is a chance that a learner would be able to acquire the skill to choose a certain technique in finding a solution to any inquiry being investigated upon at the classroom setting.

The data presented in Figure 6 suggest that the number of students who were classified in the different developmental levels vary from one country to the other. Japan, however, has the most number of students who were classified at the formal



	JAPAN	KOREA	U.S.	PHIL.
C	31.8	46.3	69.3	89.7
T	36.4	34.4	21.8	9.6
F	31.8	19.3	9.3	0.7

FIGURE 6

DEVELOPMENTAL LEVELS OF STUDENTS IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES level being 31.8% of the total samples of students from Japan. It can be noted from the data that 19.3% Korean, 9.3% American, and 0.7% Filipino students were classified to be at the fromal level based on their respective number of population. It is worthwhile to note that in all the countries, except Japan, the percentages of students who were classified to be at the concrete level were more than the percentage of students who were classified to be at the transitional level. The number of students who were classified as within the transitional level in Japan, however, is slightly higher in percentage when comppared with the concrete level students. It can therefore be stated that based on the measurement done on the reasoning skills possessed by the students, the number of students classified within the formal level were still fewer than those classified within the transitional or concrete stage.

The percentage of students classified according to the developmental levels by sex was presented in Figure 7. It could be gleaned from the data that more females seemed to have been classified as having the concrete developmental level more than the males in all countries. On the contrary, the students classified to be at the formal stage consisted of more males than females in all the countries. The number of males and females classified to be at the transitional stage seems to be equal in all the countries with the exception of the Philippines.

The percentage of students classified according to the developmental levels by grade can be seen in Figure 8. The percentage of students classified according to the grades seemed

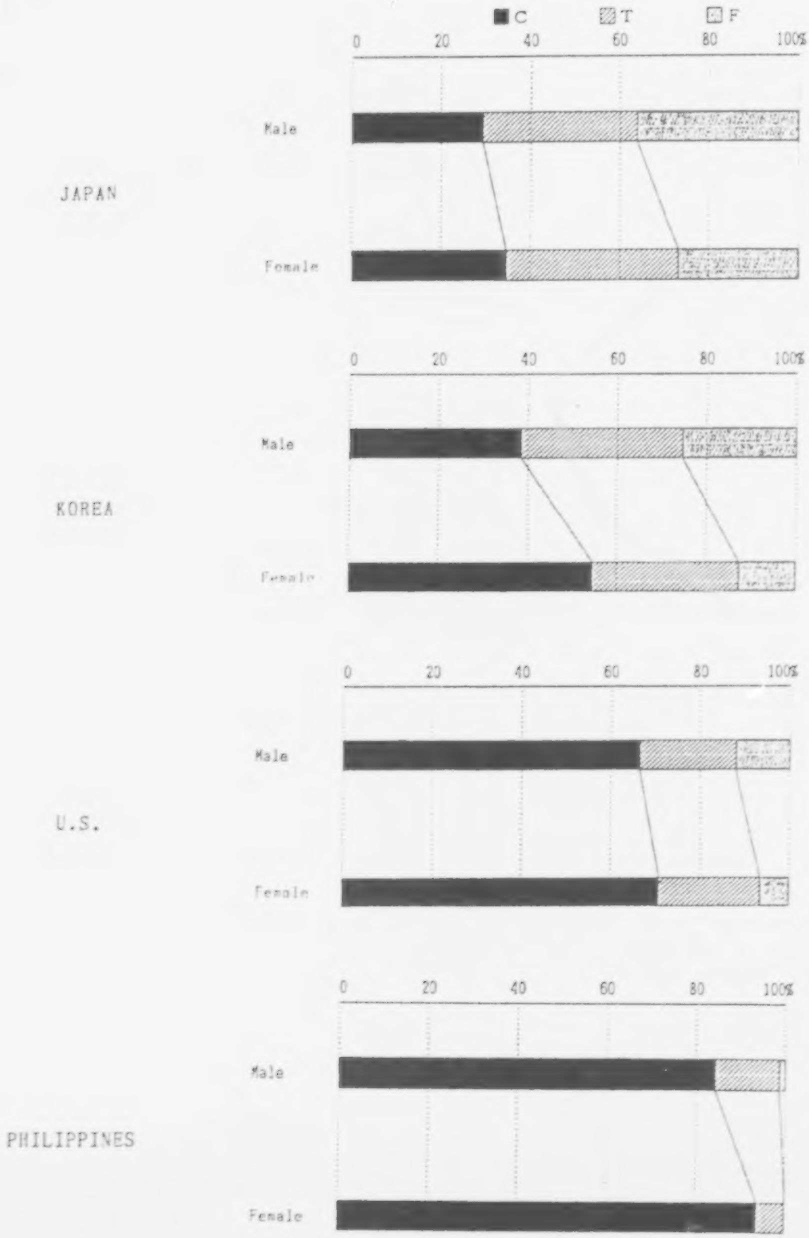


FIGURE 7

DEVELOPMENTAL LEVELS OF STUDENTS IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES, BY SEX

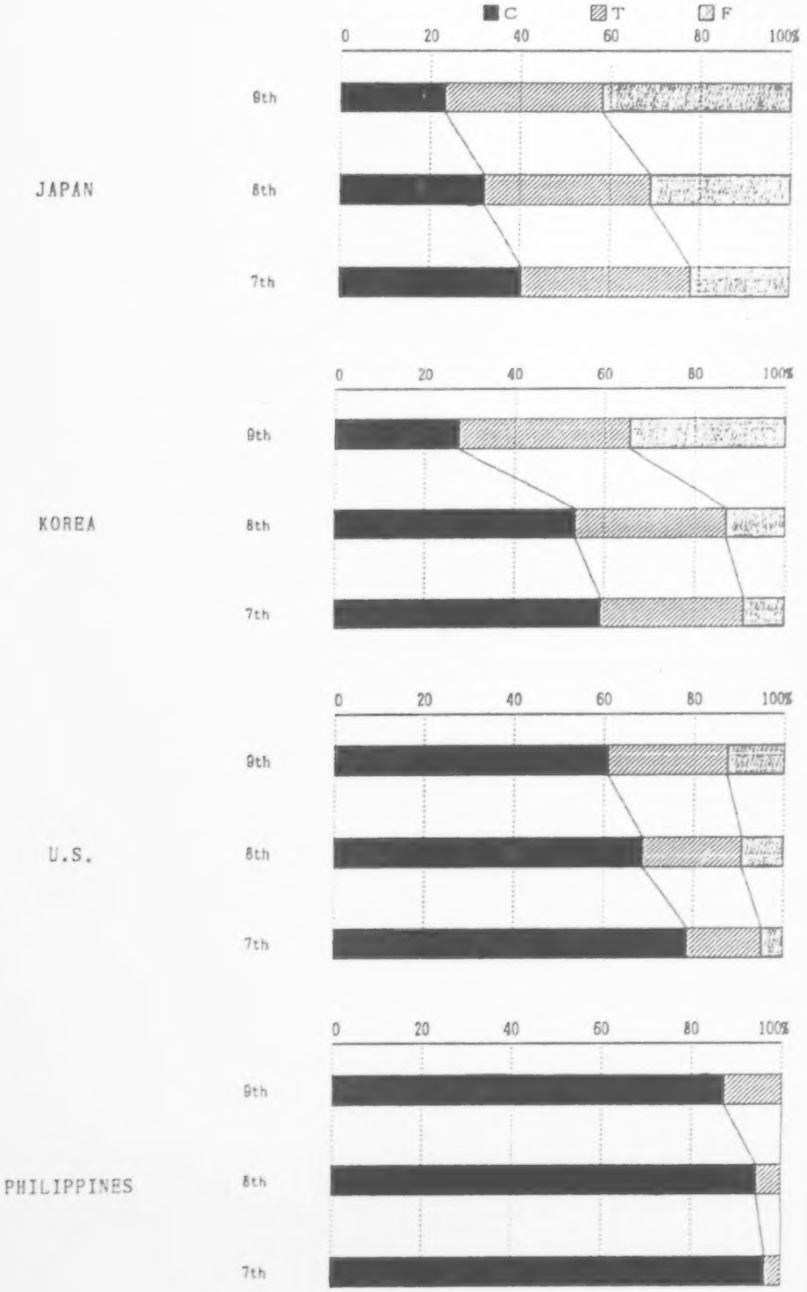


FIGURE 8

DEVELOPMENTAL LEVELS OF STUDENTS IN JAPAN, SOUTH KOREA, UNITED STATES AND THE PHILIPPINES, BY GRADE to follow an increasing pattern as they move upwards of the educational ladder in all the countries. The data exemplified the fact that more students seemed to have been classified as formal thinkers in the higher years compared to the lower years. This condition can be explained by the fact that the maturity of the students may allow them to improve their capability to deal with the reasoning skills. The experiences the students may have acquired from the school could also help them manage to solve problems related to the reasoning skills. It can therefore be postulated that the maturity as well as the school curriculum may be considered as the factors directly influencing the ability of the students to deal with the different reasoning skills that had been used to assess the developmental levels of the students.

3. Students Performance by Subscales of the Reasoning Skills

The percentage of students who were able to correctly answer the reasoning skills by subscale according to country was presented in Figure 9. It could be noted from the data from each country that Conservation (G1) and Combination (G6) were the two reasoning subscales that acquired the highest number of students who were able to answer the question on them correctly. On the other hand, the data seemed to project that the problems related to Correlation (G5) were the most difficult to answer since the percentage of students who were able to solve the problem was projected to be the lowest. The other skills such as Proportion (G2), Controlling Variables (G3), and Probability (G4) were found out to be categorized in between the easiest and the hardest

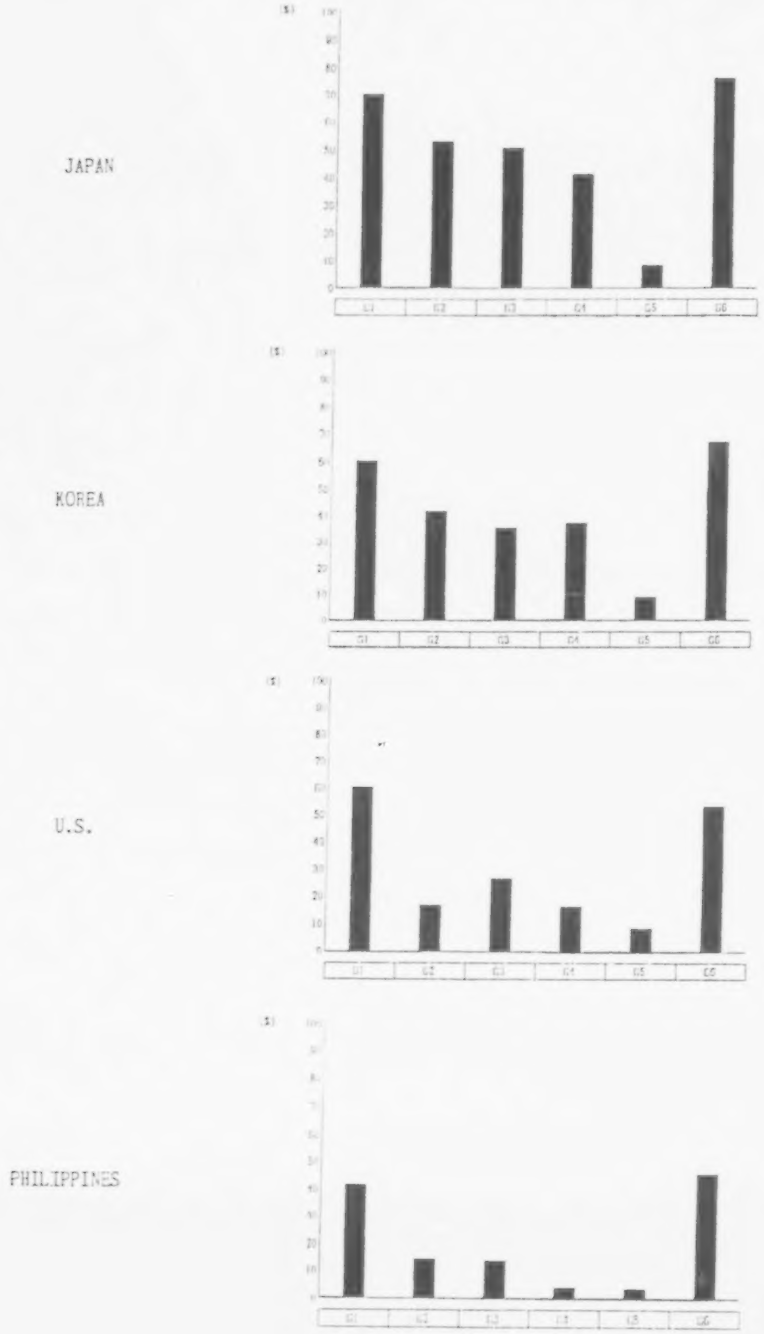


FIGURE 9
PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED EACH GALT SUBSCALE IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES

problem to be solved when the degree of difficulty were to be considered.

If the order of difficulty of problem by subscale were to be scrutinized closely, then, the common trend exist between the subjects in the Philippines and Japan since the rank of all the subskills follow a very similar pattern, that is, each subscale possesses similar rank. The ranking follows this order in an increasing pattern, to wit: Correlation (G5), Probability (G4), Controlling Variables (G3), Proportion (G2), Combination (G6), and Conservation (G1).

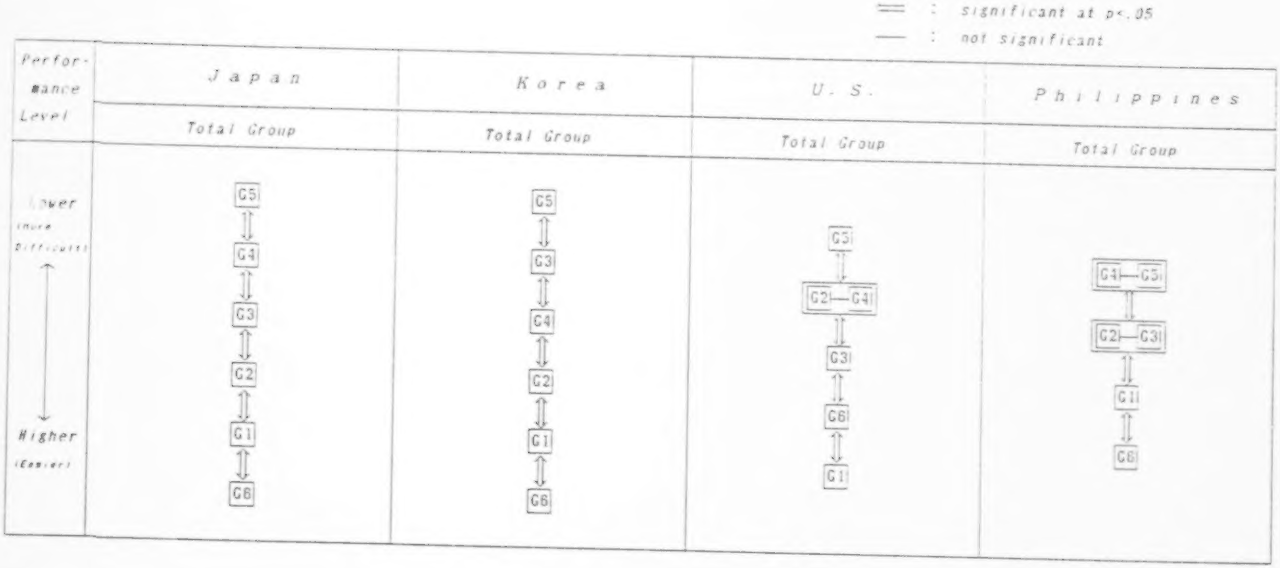
The order of the different subscales of the reasoning skills based on the degree of difficulty of the problems based on the answers of students were shown in Figure 10. It could be noted from the figure that the students from the different countries exemplified commonalities as well as differences with regard to their capacity to answer all the problem of reasoning skills by subscales. Though the statistical analysis, using the t-test, the degree of differences based among the subscales as to their being easy or difficult to respond to has been pointed out.

It could be noted from the data presented in Figure 10 that in all the countries, except the United States, the problem on Combination (G6) were considered to be easiest. The students in the United States seemed to have assumed the problems on Conservation as the easiest.

With regards to the most difficult problems to solve, it can be noted from Figure 10 that all the countries share a commonality of recording Correlation (G5) problems as the most

FIGURE 10

DIFFICULTY INDEX AMONG GALT SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES

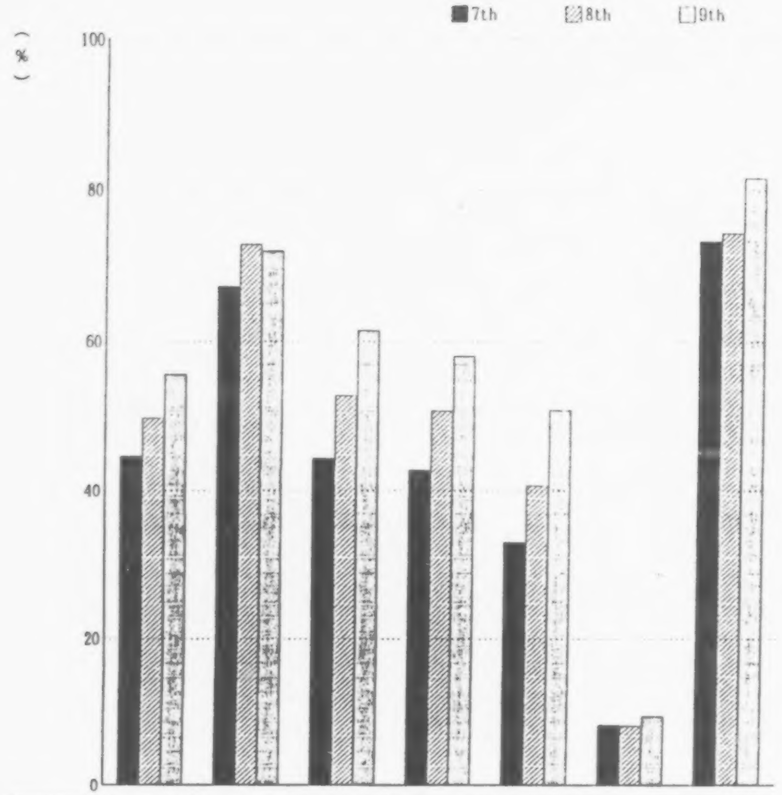

═ : significant at p<.05
— : not significant
Perfor-mance Level
Japan
Korea
U. S.
Philippines
Total Group
Total Group
Total Group
Total Group
Lower (more Difficult)
Higher (Easier)
G5
G4
G3
G2
G1
G6
G5
G3
G4
G2
G1
G6
G5
G2 — G4
G3
G6
G1
G4 — G5
G2 — G3
G1
G6

difficult. However, the data taken in the Philippines seem to suggest that Probability (G4) problem were also considered as the most difficult, since the skill was not significantly higher than that of Correlation (G5). The data further suggest that the skills on Proportion (G2) and Probability (G4) seem to be similar with their degree of difficulty as skills of the students.

The order of the skills of reasoning categorized according to their degree of being easy or difficult seemed to suggest that the students from all the countries have acquired higher scores in problems related to the concrete level problem such as those in Conservation (G1) and Combination (G6). The performance of the students may have declined in the skills such as those in Proportion (G2), Controlling Variables (G3), Probability (G4), and Correlation (G5) because these are classified as formal reasoning skills.

The difficulty of the different reasoning skills could therefore be reflected on the diversity of the percentage of students that were able to answer correctly the problems related to them. The fact that not all of the students were classified to be at the formal developmental level could explain the conditions wherein students percentage vary in all the reasoning skills.

The percentage distribution of students in GALT subscales in Japan by grade level can be seen in Figure 11. As can be seen from the data, the students from Japan seemed to depict the increase in the number of students who were able to correctly answer the questions as they move upward to the year level with the exception on the problems related to conservation and

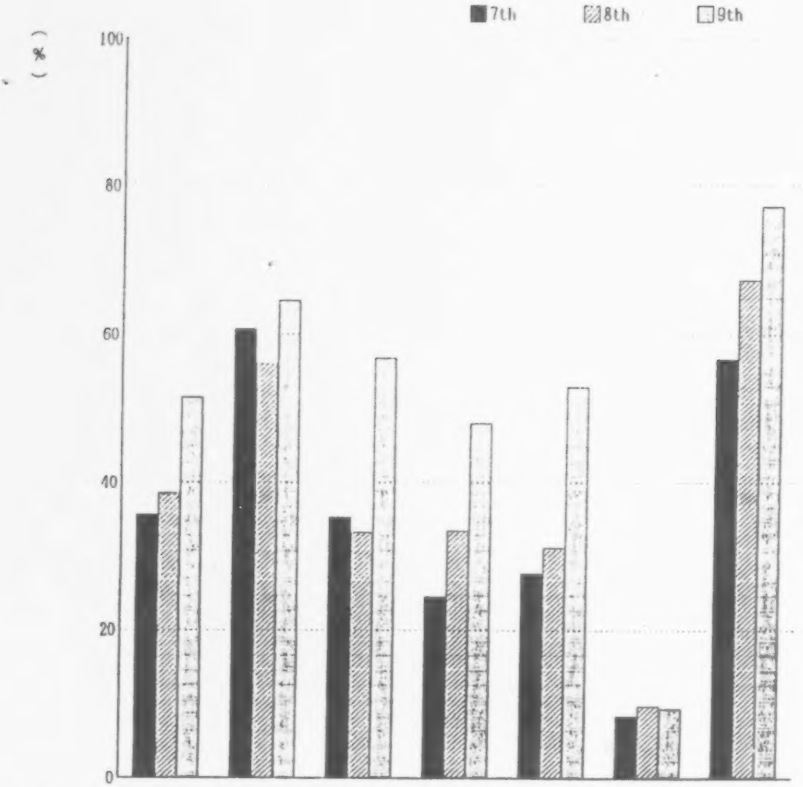


	G.T.	G1	G2	G3	G4	G5	G6
7th	44.8	67.2	44.5	42.9	32.0	8.1	73.1
8th	49.9	72.7	52.9	50.9	40.7	8.0	74.3
9th	55.6	71.8	61.5	58.2	51.0	9.4	81.6

FIGURE 11

PERCENTAGE DISTRIBUTION OF STUDENTS IN GALT SUBSCALES IN JAPAN BY GRADE LEVEL correlation. The students from Grade 8, as shown on the figure, seemed to have acquired higher percentage compared to the Grade 9 students. The Grade 8 students had the cumulative percentage of 72.7%, while the Grade 9 students only got a cumulative percentage of 71.8%. The Grade 7 students, although the difference is negligible, acquired a cumulative percentage of 81.1% while the Grade 8 students acquired a lower percentage of 80.0%. When the different grade levels were to be compared with the rank based on the increasing patterns of the percentages, then it could be observed from the figure that all the grade levels follow a common pattern in all the subscales.

The data on Figure 12 presented the percentage distribution of students in GALT subscale in the Republic of Korea by grade level. It could be observed from the data that all the grade levels follow similar pattern with regards to the rank of the different subscales as a result of the percentage of students who were able to correctly answer the questions by subscale. However, if the data were to be scrutinized closely, the ranking of some subscales vary within the year level of the students. The Grade 9 and Grade 8 students acquired a percentage making combination and conservation as ranks 1 and 2 respectively. The Grade 7 students, however, based on the percentage of students who were able to answer correctly the problem ranked conservation and combination as ranks 1 and 2 respectively. It is worth noting also that the problem on proportion, controlling variables, and probability vary on their ranks as a result of the varied performances of the students regardless of the grade level they possess. The problems



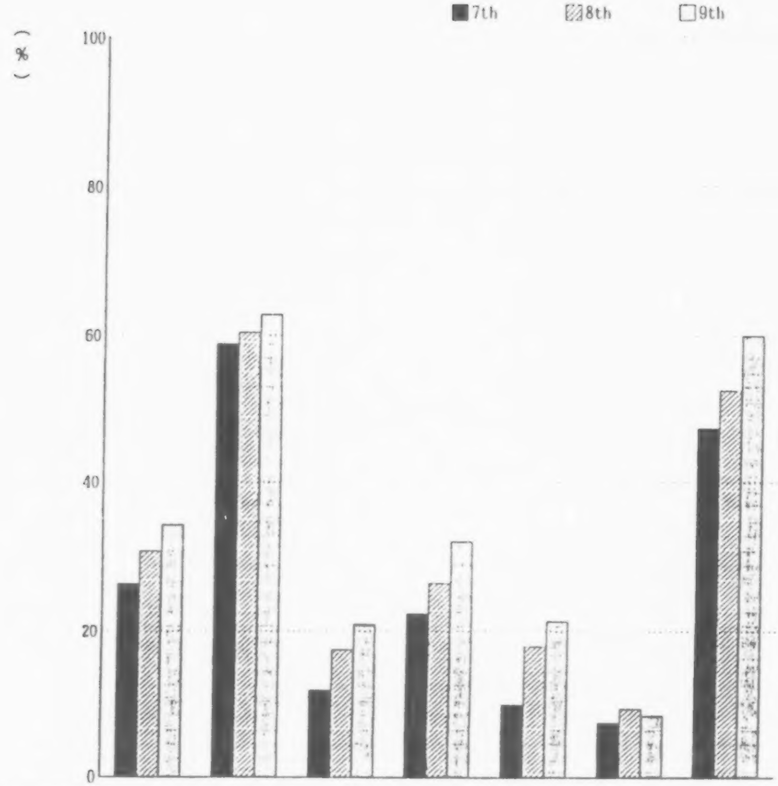
	G.T.	G1	G2	G3	G4	G5	G6
7th	35.6	60.8	35.2	24.5	27.7	8.5	56.8
8th	38.5	56.1	33.2	33.4	31.1	9.8	67.4
9th	51.5	64.6	56.9	48.0	53.0	9.5	77.3

FIGURE 12

PERCENTAGE DISTRIBUTION OF STUDENTS IN GALT SUBSCALES IN SOUTH KOREA BY GRADE LEVEL on correlation seemingly possessed the lowest rank in all the grade levels. Comparing the percentage of students in conservation by grade levels, then it could be gleaned from the data that the Grade 7 students acquired 60.8% while the Grade 8 students got a comparatively lower percentage of 56.1%. The percentage of students in proportion also follow similar rank pattern making the Grade 8 students percentage to acquire the lowest rank among the three grade levels. The problems on controlling variables, probability, and combination seemingly had been found out to increase in the number of students who were able to answer them correctly as the students progress from the lower years upward to the higher years. The data from the Republic of Korea seemed to suggest that the year level of the students does not necessarily suggest the rank of students who would be able to correctly answer the problems as a result of their grade level.

The percentage distribution of students in GALT subscales in the United States by grade level can be found in Figure 13. The data presented suggest that the percentage of the students who were able to answer correctly the problems in all the subscales, with the exception of correlation, match with the grade level of the students. The higher the grade levels the students belong to, the higher is the percentage they were able to accumulate. With regards to the problems on correlation subscale, it could be observed that the Grade 8 students acquired a little higher percentage compared to the Grade 9 students.

The percentage distribution of students in GALT subscales in

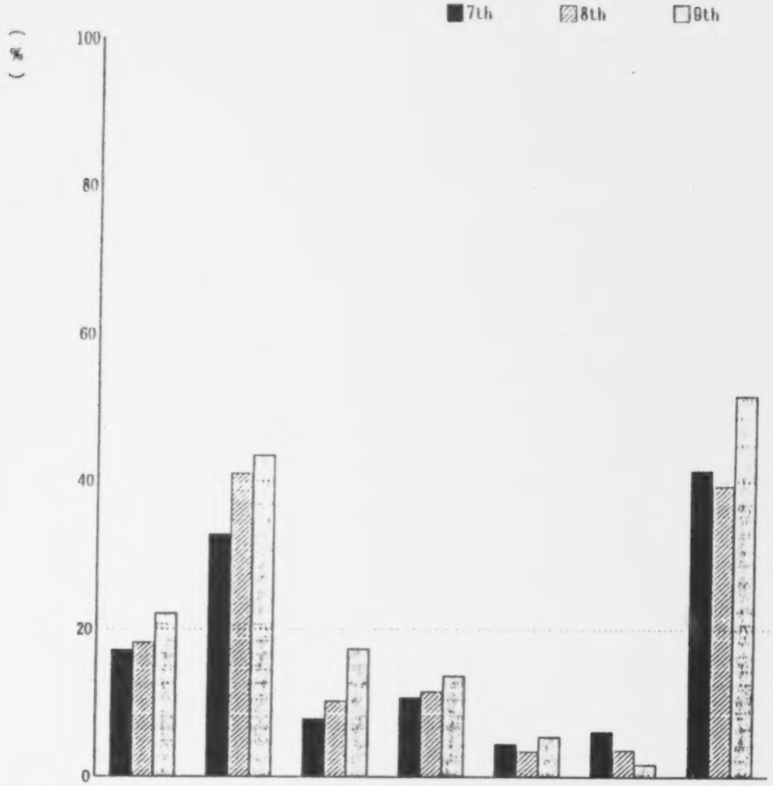


	G.T.	G1	G2	G3	G4	G5	G6
7th	26.4	59.0	12.0	22.5	10.0	7.5	47.5
8th	30.8	60.5	17.5	26.5	18.0	9.5	52.5
9th	34.3	63.0	21.0	32.0	21.5	8.5	60.0

FIGURE 13

PERCENTAGE DISTRIBUTION OF STUDENTS IN GALT SUBSCALES IN THE UNITED STATES BY GRADE LEVEL the Philippines by grade level were presented in Figure 14. The subjects from the Philippines utilized as samples in the present study seemed to have shown a relatively better performance in combinatorial reasoning and in conservation subscales comparing them with the other skills. However, the students have shown the accumulation of lower percentages in probabilistic reasoning and in correlational reasoning. The students seemed to have encountered difficulties in dealing with the problems because they have a cumulative percentage of just a little above 50% or lower in the different reasoning skills. It is observable from the data too that the student percentage by year level does not necessarily reflect the belongingness to the lower or higher grades as shown in the data by subscale. The subscales such as probability, correlation, and combination has acquired percentages of students not necessarily reflected by the grade levels they belong. The Grade 7 students acquired a higher cumulative percentage in probability and combination compared to the Grade 8 students. The students in the lower grades also acquired higher percentages than those belonging to the higher grades in the correlation subscale.

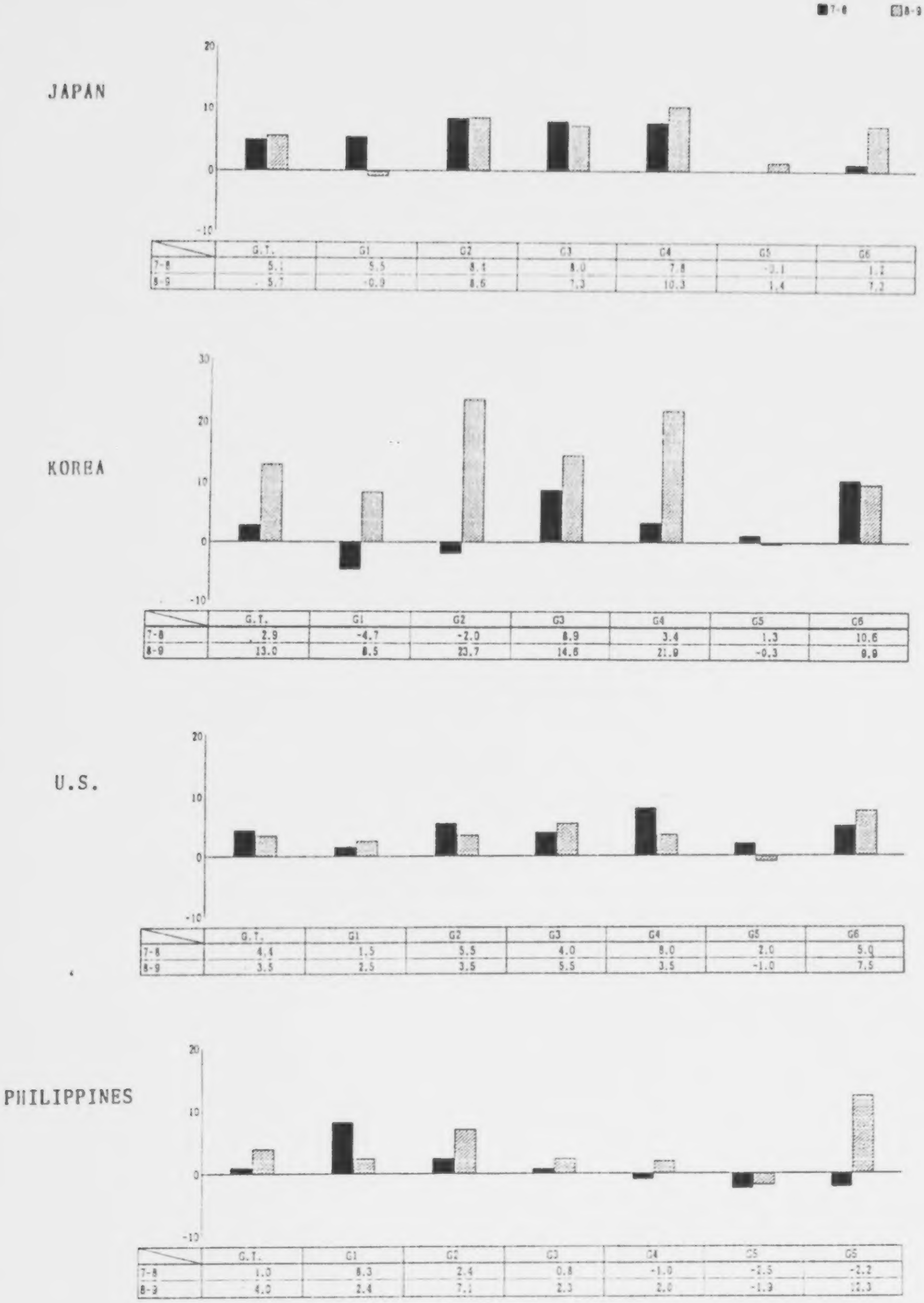
In order to understand fully the rise and fall tendency of the percentages of the students who were able to correctly answer the question by subscale and by total scores, the data from Figure 15 can be consulted. It could be gleaned from the data presented that the students from South Korea seemed to have gained the most between Grade 8 and Grade 9 (23.7), probability (21.9), and controlling variables (14.6). This gain on their



	G.T.	G1	G2	G3	G4	G5	G6
7th	17.3	32.8	7.9	10.7	4.5	6.2	41.6
8th	18.3	41.1	10.3	11.5	3.5	3.7	39.4
9th	22.3	43.5	17.4	13.8	5.5	1.8	51.7

FIGURE 14

PERCENTAGE DISTRIBUTION OF STUDENTS IN GALT SUBSCALES IN THE PHILIPPINES BY GRADE LEVEL



JAPAN

	G.T.	G1	G2	G3	G4	G5	G6
7-8	5.1	5.5	8.1	8.0	7.8	-0.1	1.2
8-9	5.7	-0.9	8.6	7.3	10.3	1.4	7.2

KOREA

	G.T.	G1	G2	G3	G4	G5	G6
7-8	2.9	-4.7	-2.0	8.9	3.4	1.3	10.6
8-9	13.0	8.5	23.7	14.6	21.9	-0.3	9.9

U.S.

	G.T.	G1	G2	G3	G4	G5	G6
7-8	4.4	1.5	5.5	4.0	8.0	2.0	5.0
8-9	3.5	2.5	3.5	5.5	3.5	-1.0	7.5

PHILIPPINES

	G.T.	G1	G2	G3	G4	G5	G6
7-8	1.0	8.3	2.4	0.8	-1.0	-2.5	-2.2
8-9	4.0	2.4	7.1	2.3	2.0	-1.9	12.3

FIGURE 15

GALT SUBSCALES GAIN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE LEVEL reasoning skills seemed to be higher compared to the result in the other countries. The data from Japan also suggest the fact that gains on the percentage of students occured in proportion, controlling variables, and probability subscales. The gain, however, existed between Grade 7 and Grade 8, as well as between Grade 8 and Grade 9. The tendency in the United States also resembles that of the data from Japan wherein the gain has become predominant too in skills such as proportion, controlling variables, and probability in all the grade levels. The increase is observable as the students move upward the educational ladder. The data from the Philippines seem to suggest a mild gain in all the subscales. The aforementioned condition can be interpreted as the result of the school curriculum as well as the teaching and learning methodologies being employed in the different school system. So, stressing the different reasoning skills within the content of the curriculum offering might have caused the variation on the gains acquired by the learners as they move upward the educational ladder.

In order to illucidate further the assumed gain acquired by the learners as they progress from one grade level to the other, the data presented in Table 3 has been made. The table showed the upward direction of the arrow, which actually reflect the significant grade progress attained by the students in each reasoning skill. The data seemed to project the condition wherein grade level gains were acquired as they progress from the lower grades to the higher grades. However, the progress attained in each reasoning skill is not the same in all the countries

TABLE 3

GALT SCORE PERCENTAGE GAIN BY GRADE LEVEL

		JAPAN		KOREA		U. S.		PHILIPPINES	
		Score Gain	Pattern 7th 8th 9th	Score Gain	Pattern 7th 8th 9th	Score Gain	Pattern 7th 8th 9th	Score Gain	Pattern 7th 8th 9th
GALT Total	7-8	• + 5.1	↗	• + 2.9	↗	• + 4.4	↗	NS + 1.0	—↗
	8-9	• + 5.7		• +13.0		• + 3.5		• + 4.0	
G1 Conservation	7-8	• + 5.5	↗→	• - 4.7	↘↗	NS + 1.5	→	• + 8.3	↗→
	8-9	NS - 0.9		• + 8.5		NS + 2.5		NS + 2.4	
G2 Proportional Reasoning	7-8	• + 8.4	↗	NS - 2.0	—↗	• + 5.5	↗	NS + 2.1	—↗
	8-9	• + 8.6		• +23.7		• + 3.5		• + 7.1	
G3 Controlling Variables	7-8	• + 8.0	↗	• + 8.9	↗	• + 4.0	↗	NS + 0.3	→
	8-9	• + 7.3		• +14.6		• + 5.5		NS + 2.3	
G4 Probabilistic Reasoning	7-8	• + 7.8	↗	NS + 3.4	—↗	• + 8.0	↗	NS - 1.0	→
	8-9	• +10.3		• +21.9		• + 3.5		NS + 2.0	
G5 Correlational Reasoning	7-8	NS - 0.1	→	NS + 1.3	→	• + 2.0	↗→	• - 2.5	↘
	8-9	NS + 1.4		NS - 0.3		NS - 1.0		• - 1.9	
G6 Combinatorial Reasoning	7-8	NS + 1.2	—↗	• +10.6	↗	• + 5.0	↗	NS - 2.2	—↗
	8-9	• + 7.3		• + 9.9		• + 7.5		• +12.3	

concerned. The conservation skill seemed to have shown a little gain between the year levels. The gain on conservation seemingly have been significant only between Grade 7 and Grade 8 as shown by the data from Japan and the Philippines. The data from the Republic of Korea about conservation suggest that a negative gain occured between the Grade 7 and Grade 8. This could probably be explained by the fact that conservation is one of the concrete tasks, and so even at the lower grades, the skill is already within their capability. The data on correlational reasoning seemed to project also a condition wherein no significant gain have been attained by the students from the countries, except between Grade 7 and Grade 8 of the data from the United States. The problem on correlational reasoning is a part of the formal thinking skill and so not all of the students were able to acquire it even though their age is already chronologically categorized as a part of the formal level of thinking.

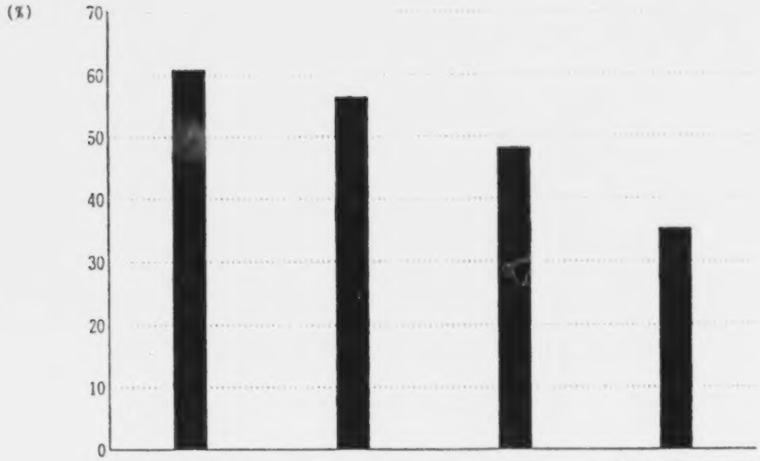
B. SCIENCE PROCESS SKILLS POSSESSED BY THE STUDENTS

The other scientific thinking skill that was included in their study was on the science process skills. Science process skills are known to be used by teachers in their classroom because of their strong desire of showing accurately the nature of science and the common activities that the scientist oftenly do to the different learners. It was stated by some researchers that the process skills commonly utilized in the science field at the secondary level fo the educational system incorporate the growth of formal operational abilities of the learners.

1. Total Science Process Skills

The percentage of the students who were able to answer the TIPS subscales as a whole in Japan, Republic of Korea, United States, and the Philippines as affected by the sex and grade level of the students were shown in Figures 16, 17, and 18 respectively. It can be gleaned from Figure 16 that the students from Japan and the Republic of Korea were accumulated more than 50% of the samples who were able to answer correctly the different subscales of the process skills such as identifying and stating hypothesis, identifying variables, defining operationally, designing investigations, and graphing and interpreting data. Using the same subscales, the average percentage of the students from the United States and the Philippines who were able to answer correctly the question accumulated less than 50% of all the respective examinees in each country.

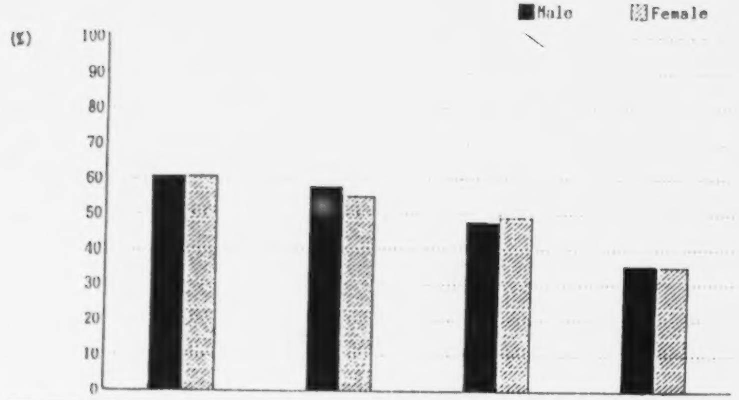
The percentage of students who were able to correctly answer the subscales of the process skills test in science categorized according to sex were shown in Figure 17. It could be noted from the data that the male students seemingly acquired higher cumulative percentage than the females in countries like the Republic of Korea and the Philippines. The females acquired higher percentage than the males with regard to the United States data. The data from Japan, however, showed a similar cumulative percentage for both males and females. The condition could probably be explained by the fact that the skills on the different processes could be mastered by the students within the



J.	K.	U.	P.
60.9	56.4	48.2	35.2

FIGURE 16

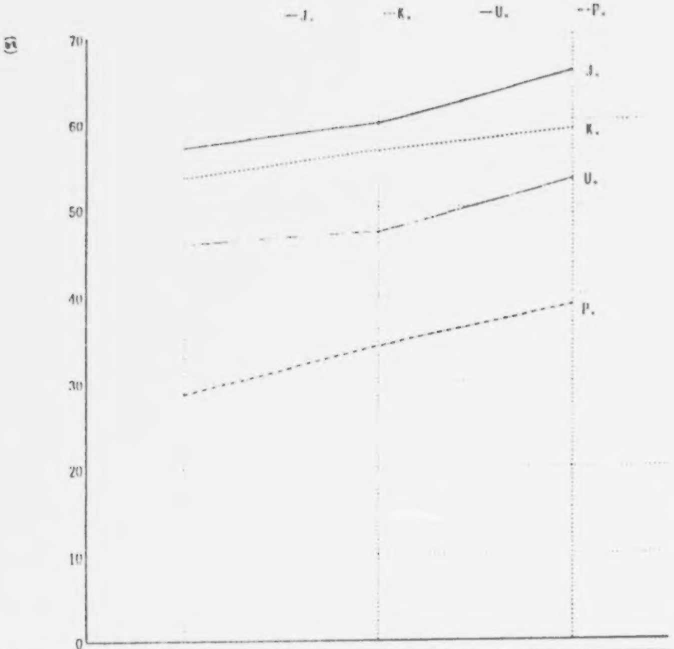
PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED TIPS SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES



	J.	K.	U.	P.
Male	60.9	57.7	47.9	35.4
Female	60.9	55.0	49.2	35.1

FIGURE 17

PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED TIPS SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY SEX



	7th	8th	9th
J.	57.1	59.8	65.6
K.	53.7	56.6	58.8
U.	46.1	47.2	53.1
P.	28.7	34.1	38.6

FIGURE 18

PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED TIPS SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE LEVEL science classroom condition without prejudice of the kind of sex one belongs to. Since these experiences about the different process skills might have been included in the science courses for both males and females, then a wide disparity, on their achievement can be eliminated.

The percentage of students who were able to correctly answer the different process skill subscales in the countries involved in the study as a result of their educational grade level were shown in Figure 18. It can be gleaned from the data that there seemed a progression on the capability of the students to deal with the process skills as they progress from the lower grades to the higher grades. The students from Japan seemed to have gained more progress on the process skills between Grade 8 and Grade 9. That condition is also observable from the data taken from the United States. On the hand, however, the students from both Republic of Korea and the Philippines apparently showed a decline on the percentage of students who can deal easily with the process skills problems by subscales as shown by the downward curve between Grade 7 and Grade 9.

The differences of the students' performance as a result of sex and grade level on the different subscales of the process skills were shown Table 4. The data presented suggest no significant difference between the performance of males and females on the different subscales of the process skills. The male students from the Republic of South Korea, however, were found out to have significantly outsmarted the female students. On the other hand, the female students from the United States

TABLE 4

CORRECT RESPONSES IN ALL TIPS SUBSCALES IN PERCENT BY SEX AND GRADE LEVELS

	JAPAN	KOREA	U.S.	PHILIPPINES
Total Group	60.9	56.4	48.2	35.2
Male	60.9	57.7	47.9	35.4
Female	60.9	55.0	49.2	35.1
Sex Difference (df=1)	F=0.01NS	F=14.04••	F=4.52•	F=0.37NS
7th	57.1	53.7	46.1	28.7
8th	59.8	56.6	47.2	34.1
9th	65.6	58.8	53.1	38.6
Grade Difference (df=2)	F=80.81••	F=17.55••	F=65.91••	F=62.34••

acquired a significantly better performance on the process skills compared with the males. The significant differences of the performance of the students by grade levels seemingly have been projected in the data shown in Table 4. The students who belong to the higher grade levels acquired better performance than those who belong to the lower grade levels. Their tendency was found out to be common in all the countries involved in the study.

2. Performance of Students by TIPS Subscale

The performance of the students determined by the percentage of those who were able to answer correctly the different process skills subscales by country were presented in Figure 19. Looking at the data, it would be possible to state that the students in all the countries were able to acquire the highest percentage of those who correctly answered the question on designing investigations skills. The data from the countries, except the United States, seemed to project the identifying and stating hypothesis as the skill with the lowest percentage of students who were able to get it. The lowest percentage for the students in the United States was on the skill of identifying variables. The data from the different countries seemed to be very similar in pattern since all the subscales show a total development as shown by tthe almost similar percentage of the students whose responses were considered to be right.

In order to have a clearer understanding about the interrelationships of the different subscales as to their being easy or difficult to be responded to by the students, the

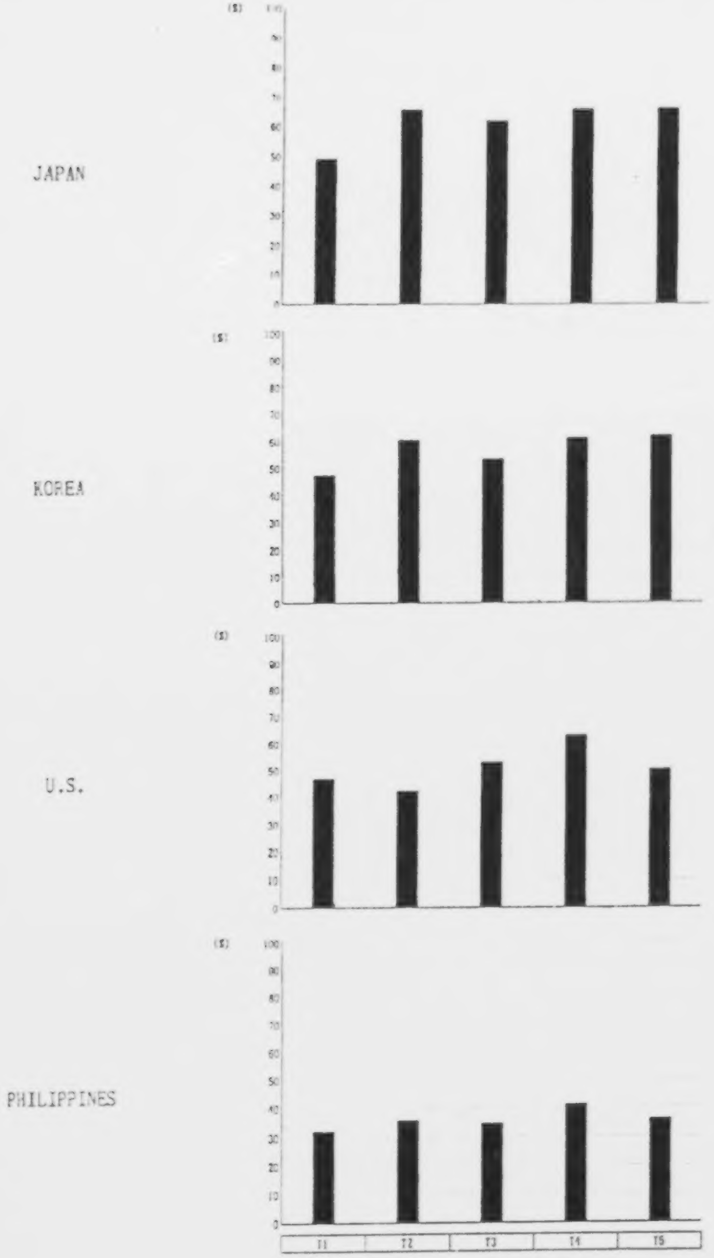


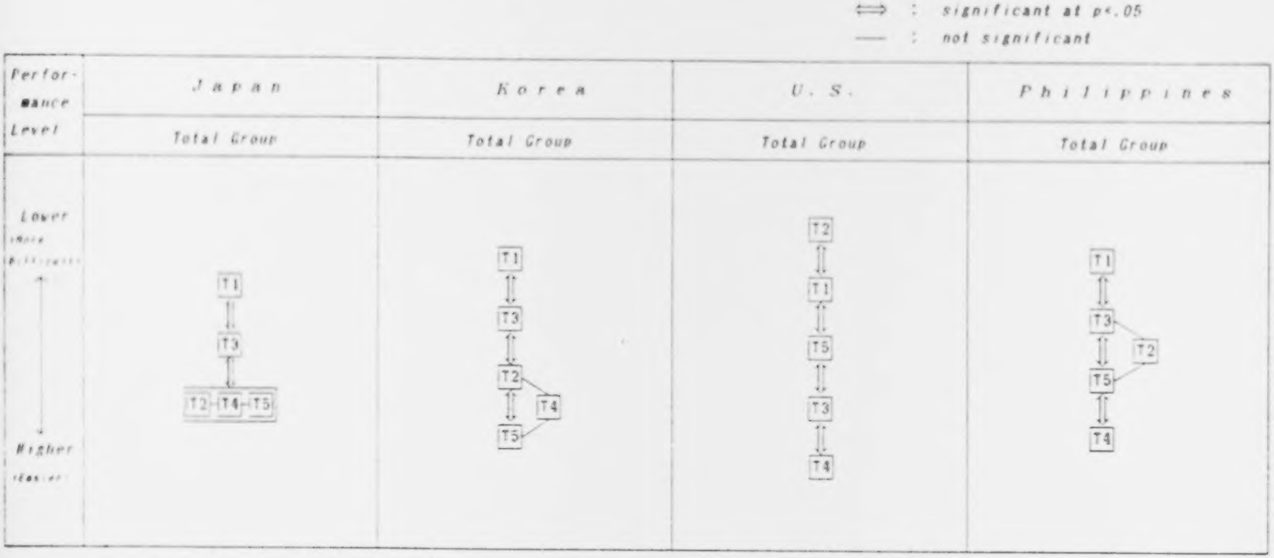
FIGURE 19

PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED EACH TIPS SUBSCALE IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES difficulty index among the subscales of the process skills were presented on Figure 20. As can be gleaned on the figure, the problem on iddentifying and stating variables acquired the smallest percentage of students with the right responses in all the countries, except that of the United States, thereby categorizing it as the most difficult. The problems on identifying variables were classified as the most difficult in the case of the responses made by the students from the United States. The data from the United States too were found out to show significant differences of the various subscales in order from the easiest to the most difficult shown as follows: designing investigation, defining operationally, graphing and interpreting data, identifying and stating hypothesis, and identifying variables. The students in Japan showed the status wherein their performance in skills such as identifying variables, designing investigations, and graphing and interpreting data were found out to be possessing no significant differences with regards to their being the easiest process skills. If the responses of the students in sll the countries were to be used as the bases of the degree of difficulties of the process skills, then graphing and interpreting data, and designing investigations can be easily classified as the easiest among the process skills in which the students could with.

The percentage distribution of the students according to the different subscales in all the countries by grade level were shown in Figures 21 - 24. It could be noted from the data that the students were able to acquire the higher percentage

FIGURE 20

DIFFICULTY INDEX AMONG TIPS SUBSCLAES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES


⟺ : significant at p<.05
— : not significant
Performance Level
Japan
Korea
U. S.
Philippines
Total Group
Total Group
Total Group
Total Group
Lower (More Difficult)
Higher (Easier)
T1
T3
T2
T4
T5
T1
T3
T2
T4
T5
T2
T1
T5
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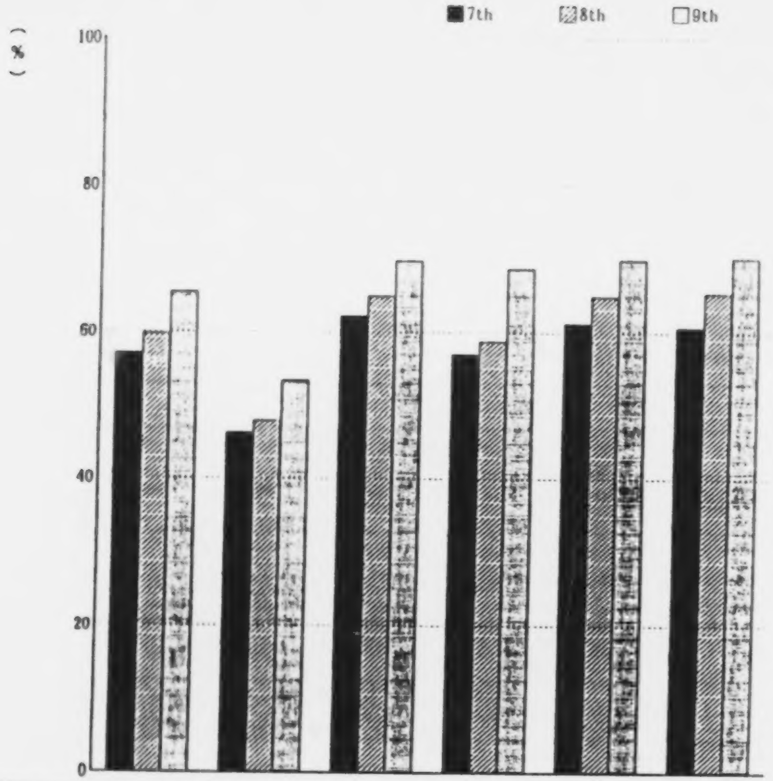
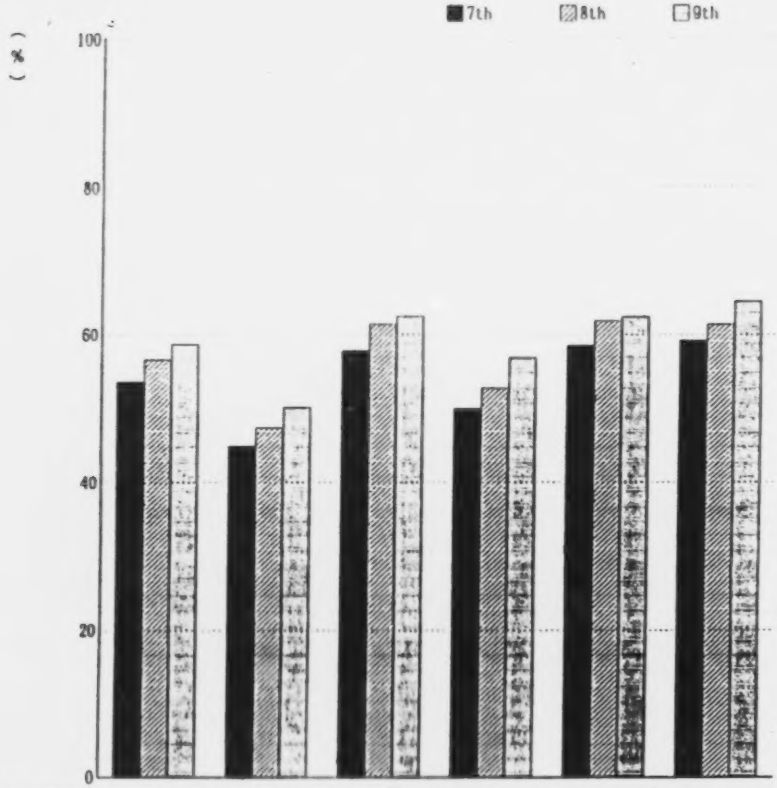
T4
T1
T3
T2
T5
T4



	T.T	T1	T2	T3	T4	T5
7th	57.1	46.3	62.3	57.0	61.3	60.8
8th	59.8	48.0	65.0	58.9	65.0	65.5
9th	65.6	53.4	69.8	68.7	70.0	70.3

FIGURE 21

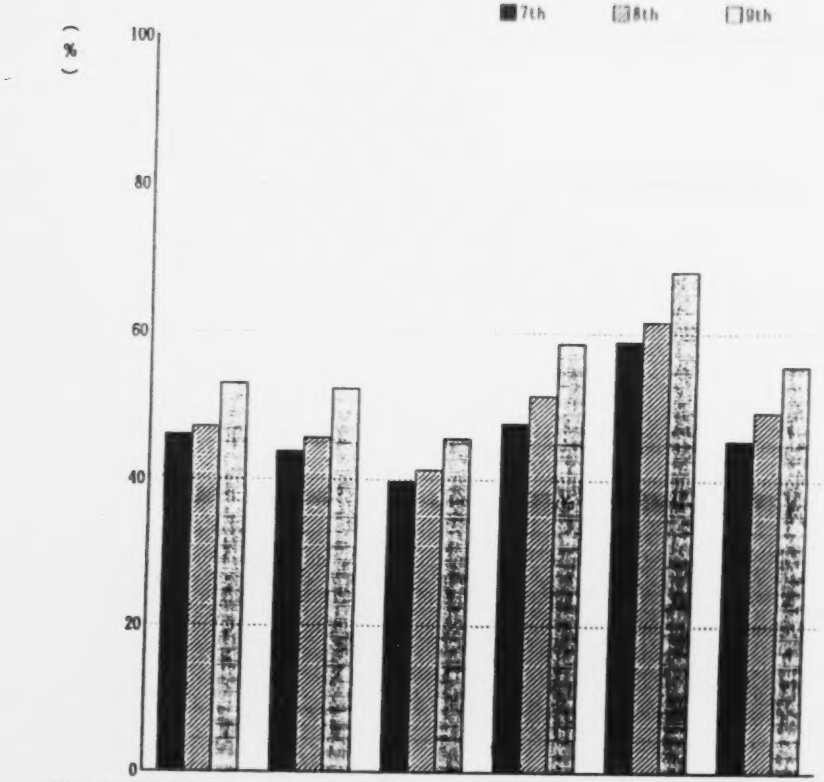
PERCENTAGE DISTRIBUTION OF STUDENTS IN TIPS SUBSCALES IN JAPAN BY GRADE LEVEL



	T.T.	T1	T2	T3	T4	T5
7th	53.7	45.1	57.9	50.1	58.6	59.2
8th	56.6	47.5	61.5	52.9	61.9	61.5
9th	58.8	50.3	62.6	56.9	62.5	64.4

FIGURE 22

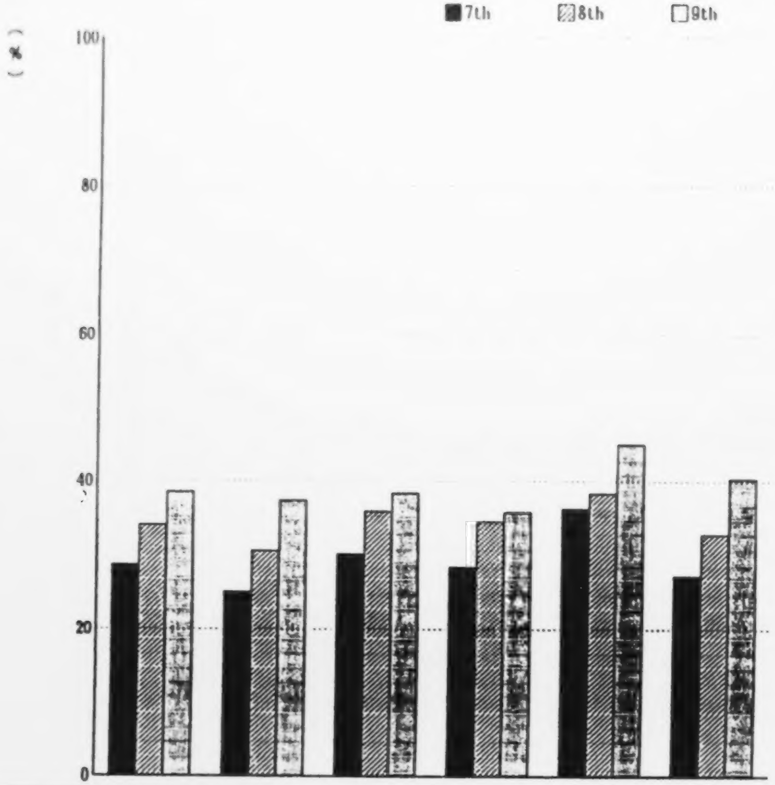
PERCENTAGE DISTRIBUTION OF STUDENTS IN TIPS SUBSCALES
IN SOUTH KOREA BY GRADE LEVEL



	T.T.	T1	T2	T3	T4	T5
7th	46.1	43.7	39.8	47.8	59.0	45.5
8th	47.2	45.8	41.3	51.5	61.7	49.5
9th	53.1	52.4	45.7	58.7	68.3	55.7

FIGURE 23

PERCENTAGE DISTRIBUTION OF STUDENTS IN TIPS SUBSCALES IN THE UNITED STATES BY GRADE LEVEL



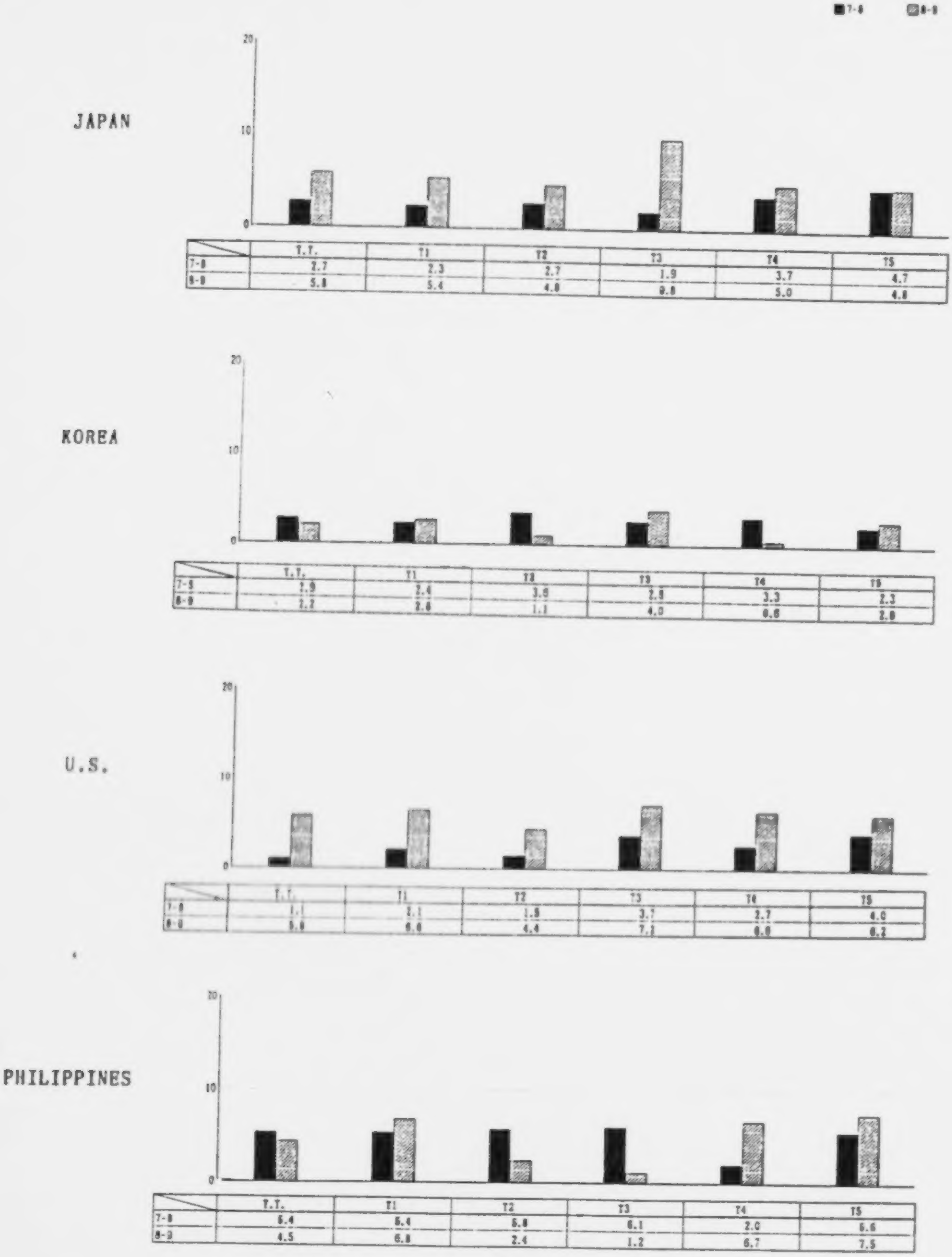
	T.T.	T1	T2	T3	T4	T5
7th	28.7	25.2	30.2	28.5	36.4	27.3
8th	34.1	30.6	36.0	34.6	38.4	32.9
9th	38.6	37.4	38.4	35.8	45.1	40.4

FIGURE 24

PERCENTAGE DISTRIBUTION OF STUDENTS IN TIPS SUBSCALES IN THE PHILIPPINES BY GRADE LEVEL commensurate to their educational levels, that is, the higher grade they belong to, then the higher percentage of students were able to get the correct responses too in the different subscales. The Grade 9 students therefore were able to have a cumulative number of students with the correct responses more than those of the Grade 8 students. The Grade 8 students similarly surpassed the Grade 7 students. The students from all the countries, based on the percentages they have acquired by subscales, therefore were able to project a total percentage which also follow the ranking as determined by the grade levels of the students.

The gains of the students based on their having correctly answered the different subscales by grade levels were shown on Figure 25. The gain patterns based on the students' performances in the four countries can be categorized into two. The first pattern, exemplifying the performance of the students from Republic of Korea and the Philippines, suggests that the students were able to acquire higher gain between Grade 7 and Grade 8 than that of Grade 8 and Grade 9 as shown by the accumulated percentage in the total process skills. The second pattern suggests that the students were able to acquire more gains between Grade 8 and Grade 9 with regard to their performance on the total process skills as shown in countries such as Japan and the United States.

The percentage of students' gain by grade levels on the different process skills in science were presented in Table 5. The information presented in Table 5 can easily be interpreted to be showing a positive increase on the ability of the students to



JAPAN

	T.T.	T1	T2	T3	T4	T5
7-8	2.7	2.3	2.7	1.9	3.7	4.7
8-9	5.8	5.4	4.8	9.8	5.0	4.8

KOREA

	T.T.	T1	T2	T3	T4	T5
7-8	2.9	2.4	3.6	2.8	3.3	2.3
8-9	2.2	2.6	1.1	4.0	0.6	2.8

U.S.

	T.T.	T1	T2	T3	T4	T5
7-8	1.1	2.1	1.8	3.7	2.7	4.0
8-9	5.9	6.6	4.4	7.2	6.6	6.2

PHILIPPINES

	T.T.	T1	T2	T3	T4	T5
7-8	5.4	5.4	5.8	6.1	2.0	5.6
8-9	4.5	6.8	2.4	1.2	6.7	7.5

FIGURE 25

TIPS SUBSCALES GAIN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE LEVEL

TABLE 5

TIPS SCORE PERCENTAGE GAIN BY GRADE LEVEL

		JAPAN		KOREA		U. S.		PHILIPPINES	
		Score Gain	Pattern 7th 8th 9th	Score Gain	Pattern 7th 8th 9th	Score Gain	Pattern 7th 8th 9th	Score Gain	Pattern 7th 8th 9th
TIPS Total	7-8	• + 2.7	↗	• + 2.9	↗	• + 1.1	↗	• + 5.4	↗
	8-9	• + 5.8		• + 2.2		• + 5.9		• + 4.5	
T1 Stating Hypothesis	7-8	• + 2.3	↗	• + 2.4	↗	• + 2.1	↗	• + 5.4	↗
	8-9	• + 5.4		• + 2.8		• + 6.6		• + 6.8	
T2 Identifying Variables	7-8	• + 2.7	↗	• + 3.6	↗→	• + 1.5	↗	• + 5.8	↗
	8-9	• + 4.8		NS + 1.1		• + 4.4		• + 2.4	
T3 Operationally Defining	7-8	NS + 1.9	—↗	• + 2.8	↗	• + 3.7	↗	• + 6.1	↗→
	8-9	• + 9.8		• + 4.0		• + 7.2		NS + 1.2	
T4 Designing Investigations	7-8	• + 3.7	↗	• + 3.3	↗→	NS + 2.7	—↗	NS + 2.0	—↗
	8-9	• + 5.0		NS + 0.6		• + 6.6		• + 6.7	
T5 Graphing Data	7-8	• + 4.7	↗	NS + 2.3	—↗	• + 4.0	↗	• + 5.6	↗
	8-9	• + 4.8		• + 2.9		• + 6.2		• + 7.5	

do the different process skills included in this study because of the upward projection of the arrows in almost all of the subscales especially on the stating hypothesis process skill. Looking at the data from Japan, it would be easy to deduce that the operationally defining skill seem to be stagnant in between Grade 7 andd Grade 8, but began to show an abrupt progression in between Grade 8 and Grade 9. The data from the Republic of Korea showed a special condition wherein the students pprojected a reduction of gain in the higher grade levels in identifying variables and designing investigation process skills. The students from the United States also showed a progressing pattern on their capacity to deal with the process skill onn designing investigations as they progresson their grade levels. The data from the Philippines stipulated the conditions wherein the designing investigation acquired a progressing result as the students advance with their year level, and on the other hand this capacity to deal with the operationally defining declined as they move upward to the higher grades.

C. INTERRELATIONSHIP BETWEEN REASONING SKILLS AND SCIENCE PROCESS SKILLS

It was maintained by Piaget and his colleagues that students in most cases acquire clearer understanding about their lessons if they are provided with ample amount of time dealing with discovery, assimilation, and development of their aptitude to project the conceptual meaning related to them. It is therefore necessary for students in science to be able to deal with a lot of concrete learning experiences which enable them to develop their own specullations at the earlier phase of the lesson, and then actually deal with a lot of hands-on activities during the other phases of the lesson. Research findings, however, suggest that the scientific thinking skills such as the reasoning and the process skills are actually having a relationship that is considered to be positively high.

1. Correlation Analysis Between the Two Scientific Thinking Skills

The correlation coefficient matrix between the reasoning skills as measured by GALT and the science process skills as measured by TIPS is shown in Table 6. It could be noted that the reasoning skills and the process skills based on the total values depicted a positive correlation in all the skills in all the countries with just a few not significant relationships from the data taken from the Philippines and the Republic of Korea can be observed if the basis were the TIPS subscales and the correlation subscale of GALT. The data from the Philippines also showed values that were not significant using the TIPS subscales and the probability subscale of GALT. All the subscales of TIPS correlated with all the subscales of GALT when the bases were the data from the United States and Japan. All the positive correlations attained between the two scientific thinking skills in all the countries were found to be statistically significant. It can therefore be stated that both reasoning and process skills could be considered to be emphasizing the development of common specific skills that are very useful in the field of science teaching. To be able to develop on the learners to perform the various process skills in their science courses could therefore foster the development of the reasoning skills of the learners.

The intercorrelation of the different subscales of the reasoning and process skills assessment could be analyzed by using the cluster analysis. The dendogram showing the interrelationship between the subscales of the scientific thinking skills were presented in Figure 26. This dendogram has been made using the correlation coefficient values from Table 6. The reasoning skills were measured by using the GALT test with a background coming from the Piagetian Theory. The theory stipulated by Gagne' on learning hierarchy has also influenced the measurement of the process skills possessed by the learners. The TIPS test was used to assess the performance of the students with regard to the different process skills. Researchers commonly have the question in mind whether the two scientific thinking skills are really different from each other. Are these two sets of skills really independent from each other? If these two sets of skills were completely different skills then the cluster analysis in all the data from the different countries should be composed of two or more groups of clusters that could be seen in the dendogram. The data from Figure 26 does not show the existence of two clusters in any of the countries. In other words, each subscale of both the reasoning and process skills are intercorrelated with each other under one kind of cognitive ability.

TABLE 6

CORRELATION COEFFICIENT MATRIX BETWEEN GALT AND TIPS SUBSCALES

		GALT Total	G1	G2	G3	G4	G5	G6
TIPS Total	Japan	.64**	.35**	.47**	.53**	.47**	.10**	.32**
	Korea	.56**	.20**	.44**	.45**	.43**	-.01NS	.31**
	U.S	.63**	.42**	.40**	.48**	.41**	.19**	.40**
	Philippines	.45**	.31**	.36**	.21**	.04NS	-.06NS	.29**
T1	Japan	.51**	.29**	.37**	.43**	.39**	.11**	.24**
	Korea	.48**	.16**	.38**	.40**	.37**	.02NS	.24**
	U.S.	.54**	.35**	.34**	.43**	.36**	.17**	.33**
	Philippines	.34**	.21**	.30**	.14**	.04NS	-.02NS	.21**
T2	Japan	.52**	.28**	.39**	.44**	.36**	.06**	.27**
	Korea	.42**	.16**	.33**	.33**	.32**	-.02NS	.25**
	U.S.	.36**	.19**	.22**	.28**	.26**	.12**	.25**
	Philippines	.28**	.20**	.21**	.16**	.03NS	-.04NS	.16**
T3	Japan	.49**	.27**	.36**	.40**	.38**	.07**	.25**
	Korea	.42**	.14**	.36**	.33**	.33**	-.01NS	.21**
	U.S.	.50**	.35**	.32**	.37**	.32**	.15**	.31**
	Philippines	.27**	.22**	.18**	.11**	.04NS	-.06NS	.19**
T4	Japan	.45**	.27**	.33**	.38**	.33**	.07**	.22**
	Korea	.35**	.12**	.26**	.31**	.26**	.01NS	.19**
	U.S.	.45**	.34**	.27**	.36**	.27**	.11**	.29**
	Philippines	.24**	.18**	.19**	.10**	.05NS	-.02NS	.14**
T5	Japan	.50**	.27**	.39**	.40**	.38**	.06**	.26**
	Korea	.45**	.14**	.34**	.34**	.36**	-.01NS	.27**
	U.S.	.52**	.39**	.34**	.37**	.33**	.14**	.33**
	Philippines	.34**	.22**	.28**	.14**	-.02NS	-.05NS	.24**

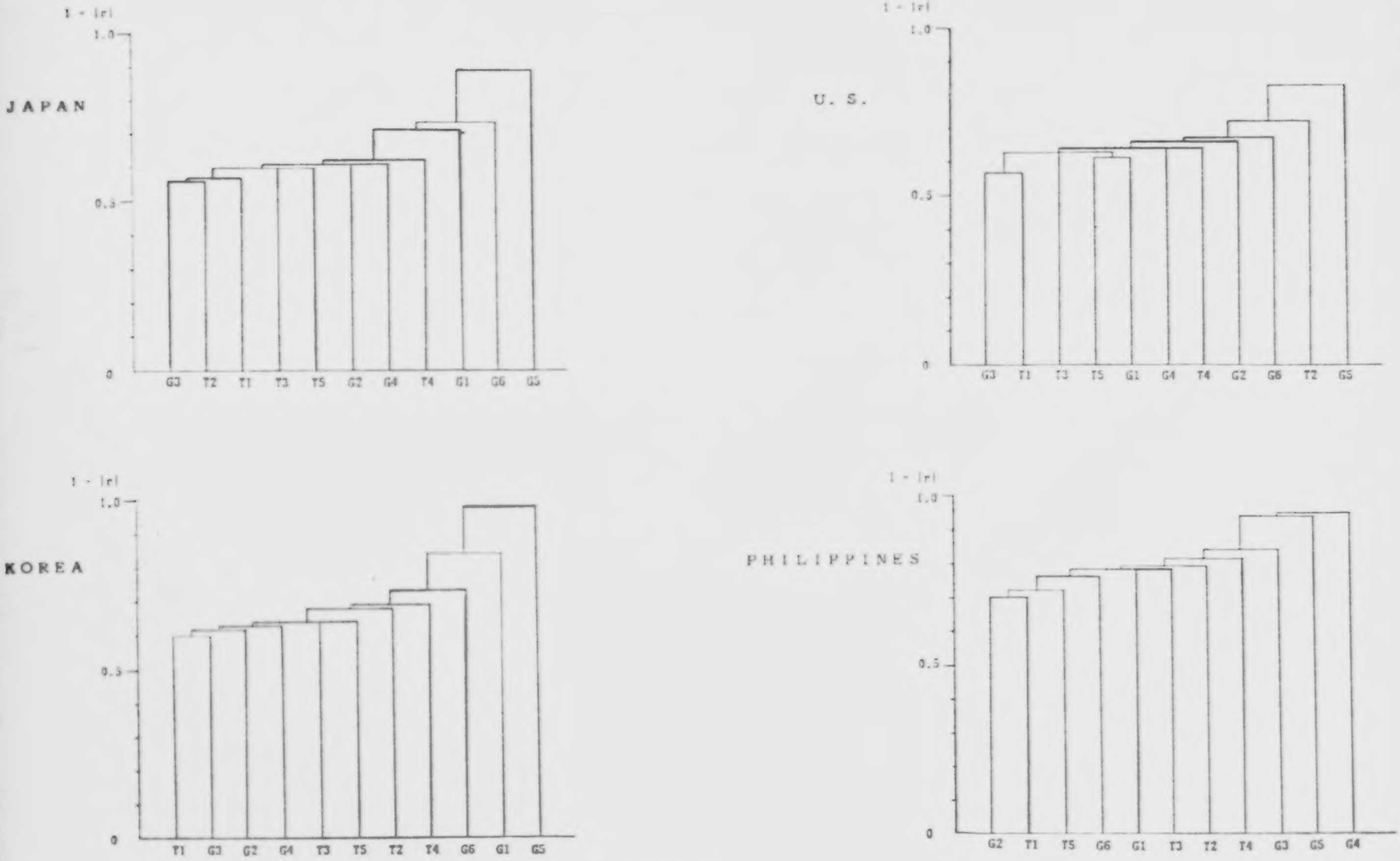


FIGURE 26

GALT AND TIPS SUBSCALES DENDOGRAM

2. The Scientific Thinking Skills Shown By Developmental Levels

The data from the different countries had been analyzed by using the distribution of the students by percentages based on their performance in the two sets of scientific thinking skills using the developmental levels as the category. The data were therefore presented by country according to the developmental levels of the students which were known as concrete, transitional, and formal.

The reasoning skills of the students based on the percentage of those who were able to correctly answer the GALT subscales by developmental levels were shown in Figure 27. It could be noted from the data that proportion (G2), controlling variables (G3), and probability (G4) seemed to have shown a development at a sequential rate from concrete to formal developmental levels. This is common in all the countries, except that probability (G4) has not followed the trend basing on the data from the Philippines. At the formal level, the skills on conservation (G1), proportion (G2), controlling variables (G3), and combination almost acquired similar performance level in all the countries. The probability (G4) skill has been found out to have acquired the highest percentage of students who were able to answer it correctly in countries such as Japan, Republic of Korea, and the United States when the formal level thinkers were to be considered. It was however found out to be the skill that acquired the lowest percentage when the formal level thinkers from the Philippines were concerned. In like manner, among the formal thinkers, the percentage of students who were able to answer correctly the problem on correlation (G5) acquired the lowest.

In order to understand better the gain in percentage of each developmental level groups, then the data found in Figure 28 can not be dispensed with. It could be noted from the data that a marked gain of each skill could be observable from concrete to transitional, and from transitional to formal. The figure therefore exemplified at which stage the students were able to acquire gain in their ability to deal with the different reasoning skills. The conservation (G1) and combination (G6) skills found out to have demonstrated a fast development during the period from concrete to transitional, a condition common among all the countries. The skill on correlation (G5) has been found to have shown development at the period from transitional to formal. This is also the trend when the probability (G4) skill is concerned in all the countries that in the Philippines where the students acquired a declining tendency in their skills. So using the data from Figure 28, it would be possible to point out the period wherein the students were able to acquire a gain in their on their capability to deal with the different reasoning skills. The different skills can be described to have acquired gain in all the developmental levels at a different rate. This condition would probably adhere to the fact that the reasoning skills are directly affected by the intellectual or cognitive development of the learners. The ability of the learners to deal with the different reasoning skills is directly related to their developmental levels.

The statistical significance of the gain acquired by the students as they progress from one developmental level to the other in the different reasoning subscales were shown in Table 7. The gain acquired by the students were illustrated using the arrow sign to allow the easy interpretation of the gains that were attained, The total of the reasoning skills depicted a commonality in the trend in which all the students from the different countries acquired gain as they proceeded from the concrete to transitional, and then from transitional to fromal stages. The significant gain has also been attained by the students , regardless of their country, on the proportion (G2) and controlling variables (G3) skills. All the gains attained by the students from the United States and Japan were found out to be significant. The gain from concrete to formal of the students from the Repuiblic of Korea with the correlational reasoning (G5) was found out to be not significant. The data from the Philippines also presented values considered not significant in the gain made at some developmental levels for conservation (G1), probability (G4), correlation (G5), and combination (G6).

The percentage of students who were able to correctly answer the process skills subscales as measured by TIPS by developmental levels in all the countries was shown in Figure 29. It could be noted from the data presented that performance level according to the developmental levels of the students seemed to have projected similarity. There seemed to be a total development of the skills on the process as the students progress from one developmental level to another. All the skills seemed to be answered by the

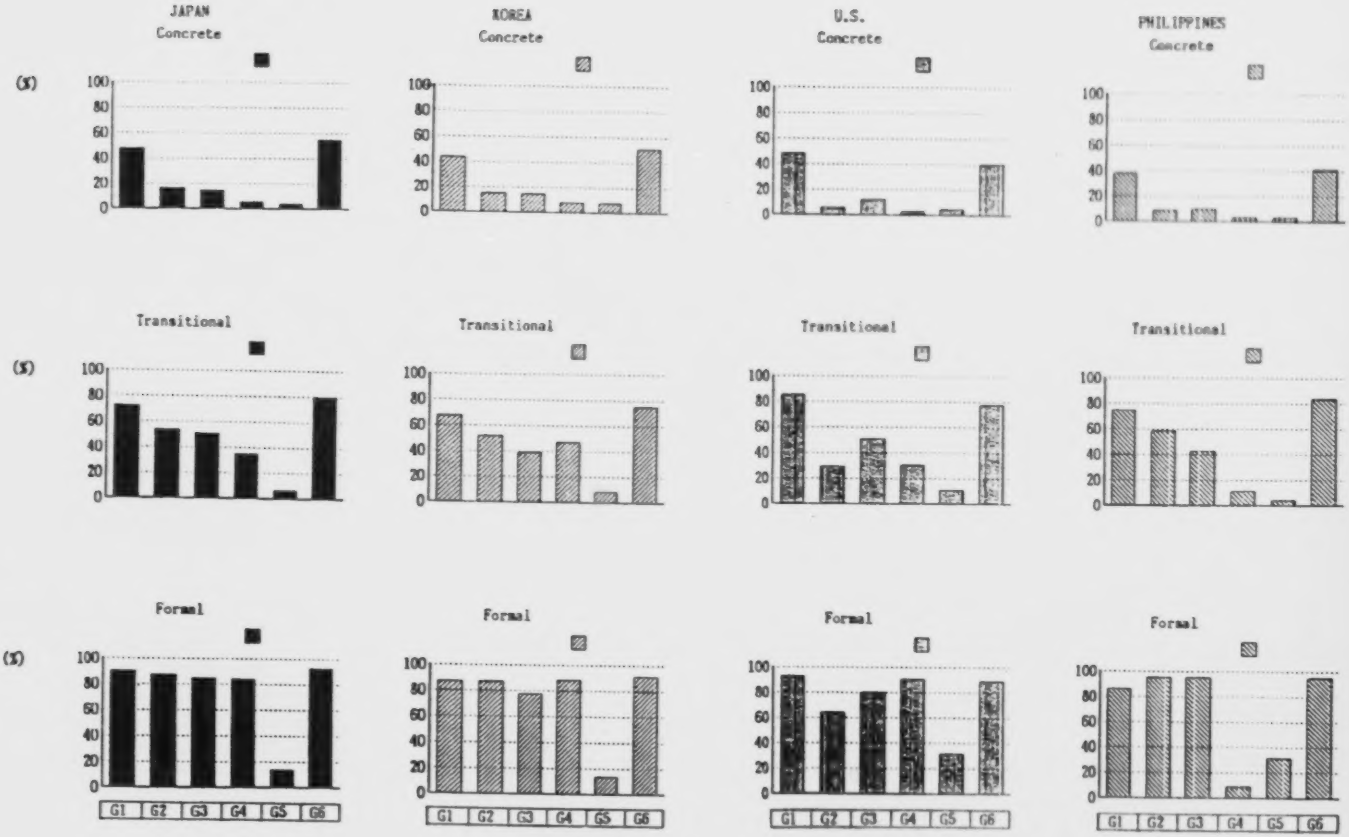
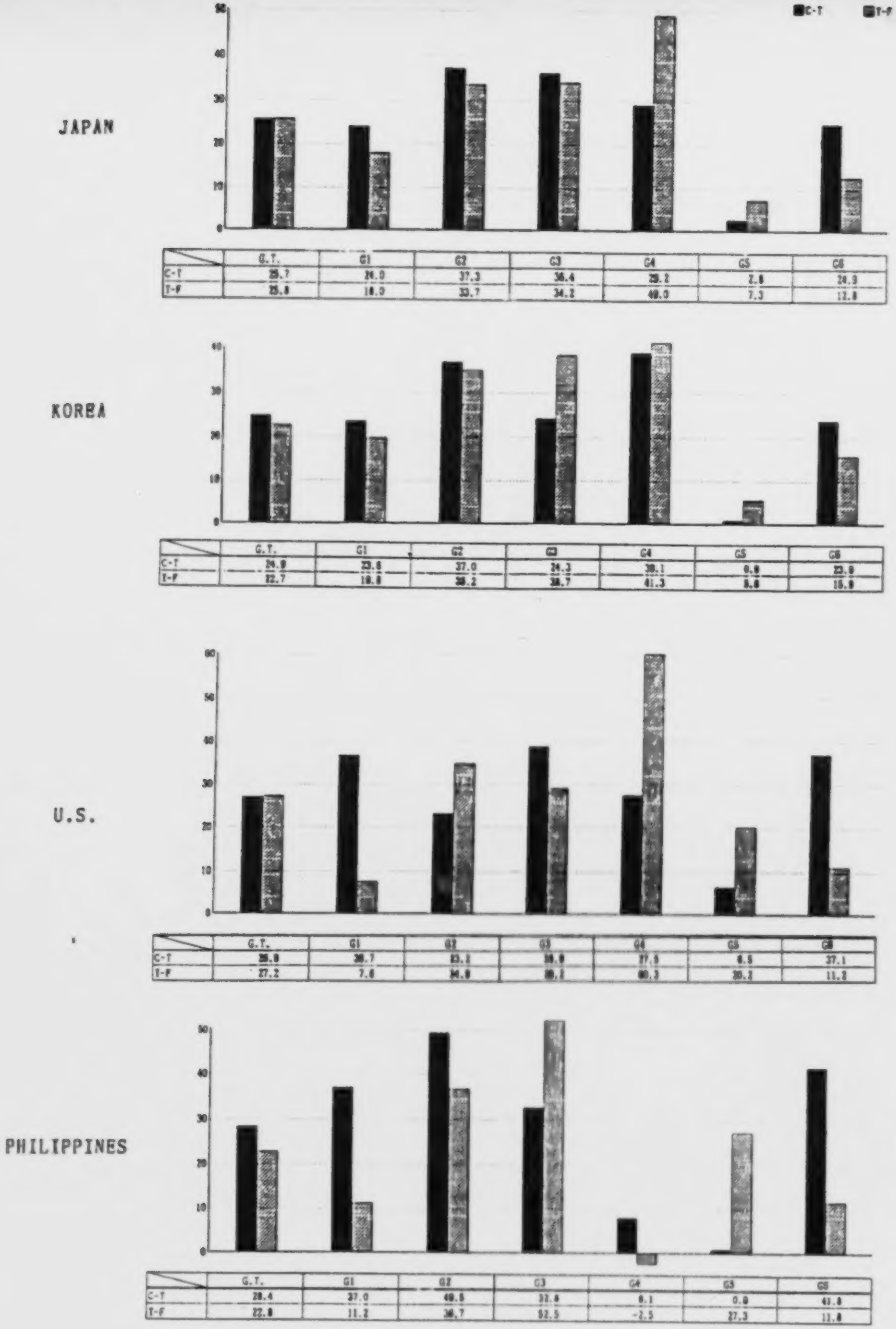


FIGURE 27

PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED GALT SUBSCALES BY DEVELOPMENTAL LEVELS



JAPAN

	G.T.	G1	G2	G3	G4	G5	G6
C-T	25.7	24.0	37.3	36.4	29.2	2.0	24.3
T-F	25.8	18.0	33.7	34.2	49.0	7.3	11.8

KOREA

	G.T.	G1	G2	G3	G4	G5	G6
C-T	24.9	23.6	37.0	24.3	38.1	0.0	23.0
T-F	22.7	19.8	35.2	38.7	41.3	4.8	15.0

U.S.

	G.T.	G1	G2	G3	G4	G5	G6
C-T	26.8	36.7	23.1	38.0	27.5	5.5	37.1
T-F	27.2	7.6	34.8	28.6	60.3	20.2	11.2

PHILIPPINES

	G.T.	G1	G2	G3	G4	G5	G6
C-T	28.4	37.0	48.8	32.8	8.1	0.0	41.8
T-F	22.8	11.2	36.7	52.5	-2.5	27.3	11.8

FIGURE 28

GALT SUBSCALES GAIN IN JAPAN, SOUTH KOREA,
UNITED STATES, AND THE PHILIPPINES BY DEVELOPMENTAL LEVELS

TABLE 7

GALT SCORE PERCENTAGE GAIN BY DEVELOPMENTAL LEVEL

		JAPAN		KOREA		U. S.		PHILIPPINES	
		Score Gain	Pattern C T F	Score Gain	Pattern C T F	Score Gain	Pattern C T F	Score Gain	Pattern C T F
GALT Total	C-T	• +25.7	↗	• +24.9	↗	• +26.9	↗	• +28.1	↗
	T-F	• +25.8		• +22.7		• +27.2		• +22.8	
G1 Conservation	C-T	• +24.0	↗	• +23.6	↗	• +36.7	↗	• +37.0	╱→
	T-F	• +18.0		• +19.3		• + 7.5		NS +11.2	
G2 Proportional Reasoning	C-T	• +37.3	↗	• +37.0	↗	• +23.2	↗	• +49.5	↗
	T-F	• +33.7		• +35.2		• +34.9		• +36.7	
G3 Controlling Variables	C-T	• +36.4	↗	• +24.3	↗	• +38.9	↗	• +32.8	↗
	T-F	• +34.2		• +38.7		• +29.2		• +52.5	
G4 Probabilistic Reasoning	C-T	• +29.2	↗	• +39.1	↗	• +27.5	↗	• + 8.1	╱→
	T-F	• +49.0		• +41.3		• +60.3		NS - 2.5	
G5 Correlational Reasoning	C-T	• + 2.8	↗	NS + 0.9	_↗	• + 6.5	↗	NS + 0.9	_↗
	T-F	• + 7.3		• + 5.6		• +20.2		• +27.3	
G6 Combinatorial Reasoning	C-T	• +24.9	↗	• +23.9	↗	• +37.1	↗	• +41.8	╱→
	T-F	• +12.8		• +15.9		• +11.2		NS +11.8	

students with commonality as depicted by the total progression of the percentage of students who were able to correctly answer the problesms, specifically if the performance were to be analyzed by developmental levels.

The data from Figure 30 presented the TIPS subscale gain the countries involved in the study by developmental levels. It could be noted from the data that the students from Japan and the Republic of Korea showed a constant gain in the different skills regardless of the developmental level being analyzed. So the students from these two countries seemingly developed constantly from the concrete to the formal developmental level. On the other hand, the students from the United States and the Philippines were observed to have acquired more gain in their skills when classified as within the concrete and transitional stages. The students categorized as a part of the transitional and formal developmental levels seemed to have a reduced rate in the gain they have acquired.

The percentage gain of the students from the different countries by developmental levels were statistically tested. The data in their calculations made were shown in Table 8. The data suggest basing on the arrow direction, that the students from the different countries acquired percentage gain in graphing and interpretation of data process skill as a result of their developmental levels. The significant difference on the gain acquired by the students from concrete to transitional, and from transitional to concrete, have been found out in this process skill. It is worthwhile to note from the data that the students

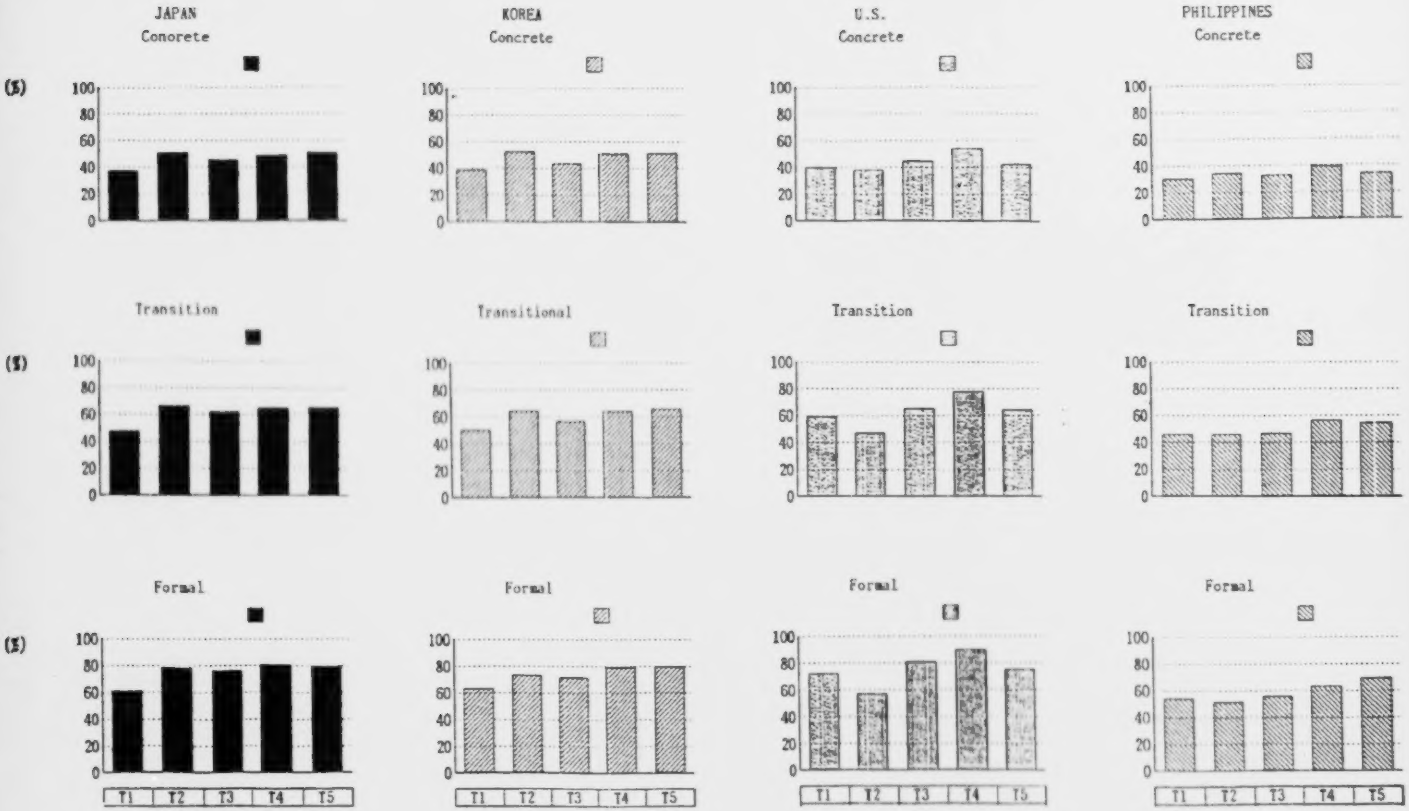
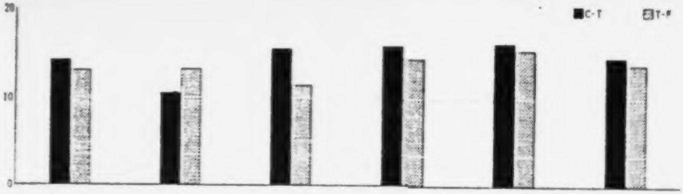


FIGURE 29

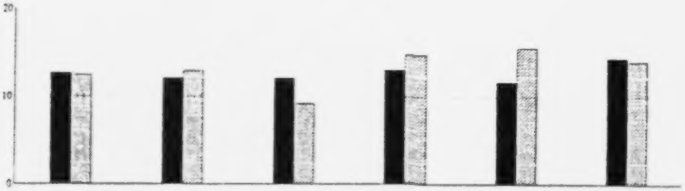
PERCENTAGE OF STUDENTS WHO CORRECTLY ANSWERED TIPS SUBSCALES, BY DEVELOPMENTAL LEVELS

JAPAN



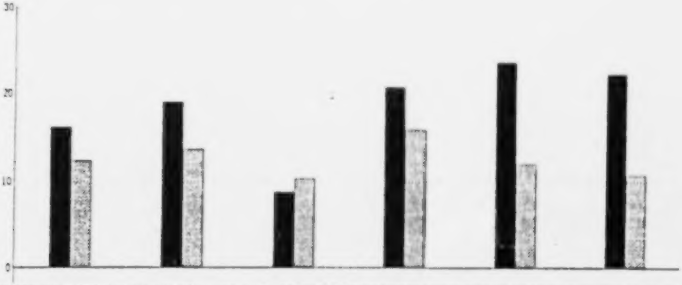
	T.T.	T1	T2	T3	T4	T5
C-T	14.4	10.6	15.7	16.0	16.4	14.8
T-F	13.3	13.4	11.6	14.7	15.6	14.0

KOREA



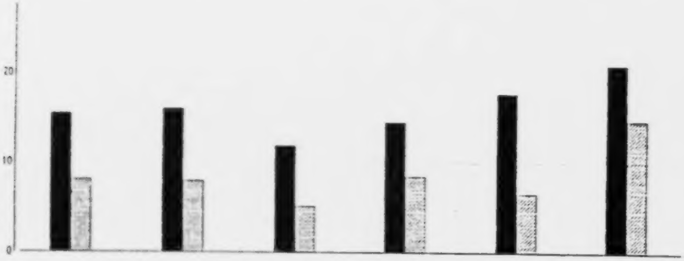
	T.T.	T1	T2	T3	T4	T5
C-T	12.6	12.1	12.1	13.0	11.7	14.4
T-F	12.4	12.9	9.2	14.8	15.6	14.0

U.S.



	T.T.	T1	T2	T3	T4	T5
C-T	16.1	19.3	8.8	20.7	23.8	22.2
T-F	12.3	13.6	10.3	15.8	12.0	10.7

PHILIPPINES



	T.T.	T1	T2	T3	T4	T5
C-T	15.4	16.0	11.8	14.5	17.5	21.1
T-F	8.1	7.9	5.1	8.4	6.6	14.7

FIGURE 30

TIPS SUBSCALES GAIN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY DEVELOPMENTAL LEVELS

TABLE 8

TIPS SCORE PERCENTAGE GAIN BY DEVELOPMENTAL LEVEL

		JAPAN		KOREA		U. S.		PHILIPPINES	
		Score Gain	Pattern C T F	Score Gain	Pattern C T F	Score Gain	Pattern C T F	Score Gain	Pattern C T F
TIPS Total	C-T	• +14.4	↗	• +12.6	↗	• +16.1	↗	• +15.4	↗→
	T-F	• +13.3		• +12.4		• +12.3		NS + 8.1	
T1 Stating Hypothesis	C-T	• +10.6	↗	• +12.1	↗	• +13.0	↗	• +16.0	↗→
	T-F	• +12.4		• +12.9		• +13.6		NS + 7.9	
T2 Identifying Variables	C-T	• +15.7	↗	• +12.1	↗	• + 8.8	↗	• +11.8	↗→
	T-F	• +11.6		• + 9.2		• +10.3		NS + 5.1	
T3 Operationally Defining	C-T	• +16.0	↗	• +13.0	↗	• +20.7	↗	• +14.5	↗→
	T-F	• +14.7		• +14.8		• +15.3		NS + 8.4	
T4 Designing Investigations	C-T	• +16.4	↗	• +11.7	↗	• +23.6	↗	• +17.8	↗→
	T-F	• +15.6		• +15.6		• +12.0		NS + 6.5	
T5 Graphing Data	C-T	• +14.8	↗	• +14.4	↗	• +22.2	↗	• +21.1	↗
	T-F	• +14.0		• +14.0		• +10.7		• +14.7	

from the Philippines seemingly have acquired a gain value which were not significant in skills such as stating hypothesis (T1), identifying variables (Y2), operationally defining (T3), and designing investigations (T4) at the period wherein they progressed from transitional to formal periods. The data seemingly suggest the possibility of continuously developing the skills as a whole as the students progress from one developmental level to the other.

Concluding Remarks

It can be gleaned from the data presented in this section about the reasoning skills that seemingly the intercorrelation between the reasoning skills and the process skills could be noted. It would be worthwhile to state however that a sequential development of the reasoning skills can be speculated due to the gradual increase in achievement from concrete to transitional, and from transitional to concrete. This could probably be explained by the fact that concepts learned from the classroom, especially in the science classes, may be giving a sizable influence on the development of the reasoning skills.

The data gathered also suggest that the process skills develop as a whole, meaning that all the skills seem to be answered correctly by the students. This could probably be explained by the interrelatedness of all the process skills. These skills are part of the problem solving processes involved in the science classes. So, these skills developed all at the same time instead of being nurtured in an independent pattern.

The skills that are commonly emphasized to be used in the classroom especially during science instructions, might have been influential on the acquisition of the processes in science skills. The experience of the learners in actually dealing with various process skills, could certainly enrich the capability of dealing with the process skills utilized in this study. Experiences in performing all these skills could help a lot in achieving good results in using the process skills.

It can be postulated that the process and reasoning skills of learners could have been directly affected by the developmental levels in which they belong. The developmental level might be interpreted as having a direct relationship with the learners I.Q. itself. The process skills, however, can be enhanced or developed on the learners through their use of suitable educational experiences geared towards the improvement of these skills.

II. THE VARIOUS CHARACTERISTICS OF THE SECONDARY SCHOOL STUDENTS

The transition from elementary to secondary school classroom conditions oftenly brings about a phase of adjustmenton the part of the learners due to variables directly related to their immediate environment. The various characteristics of the different secondary school students which included their out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons have been discussed at this section of the study because of their importance in giving a clear understanding about the effectiveness of the science teaching and learning processes. The experiences of the learners coming from their exposure to several science-related tasks could certainly help them acquire skills necessary in the course. The motivation towards science processes in which the learners possess could actually foster the better learning capacity that they could have, since the lack of this simply allows them to come to school without necessarily focusing their attention on science activiites. The topics and contents included in the science curricular offerings in all the countries actually belong to the study of nature, and so, the learners must acquire the proper feeling of loving nature. The conditions within a science classroom could also be improved fully if the students possess the positive attitude towards the different processes.

It could be said that the affective domain of the learning process certainly provide a strong positive effect on the acquisition of knowledge and skills necessary in learning science. The knowledge on the affective needs of the learners would certainly allow the provision of a safe learning environment within a science classroom.

A. THE OUT-OF-SCHOOL SCIENCE EXPERIENCES OF THE LEARNERS

In order to improve the learning capacity of the learners in dealing with the various subject areas of science, it is necessary for the teachers to allow them to acquire a lot of school and out-of-school experiences related to science. It has been stated by some educators that the content of science should be relevant to the lives of the students and should be containing contents that can be organized into meaningful and participatory learning experiences appropriate to the developmental levels of the students. As was stated by Gagne' (Hart, 1981), "the essential task of the teacher is to arrange conditions of the learner's environment so that processes of learning will be activated, supported, enhanced, and maintained". The students should therefore need opportunities to interact, share ideas, and draw upon each other's discoveries. Outside the school activities in science should also be given primordial attention.

The out-of-school science experiences mean of the students from Japan, Republic of Korea, United States, and the Philippines, were presented in Figure 31. It could be noted from the data that out the 29 items they have rated, based on their frequency of having performed them, suggest that the students from Japan and Republic of Korea seemingly have a mean rating classified to be below the qualitative "rare" scale since they acquired lower than 2 as the mean. On the other hand, the United States and the Philippines possessed students who rated their experiences to be little above the "rare" calibration. It could be deduced from the data, therefore, that the students from all the countries involved in the study encountered relatively less experience if the total mean of their ratings were to be made as the basis. The scale utilized the following calibrations: Very often, 5 ; Often, 4 ; Sometimes, 3 ; Rare, 2 ; and Never, 1. So, the different means taken from the responses of the students suggest that all the countries shared the commonality

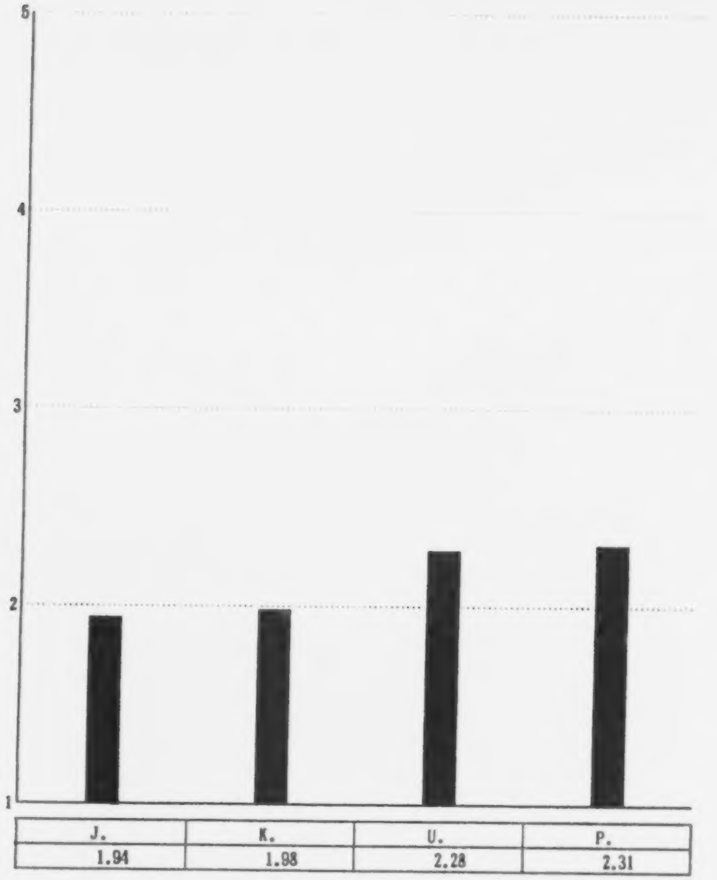
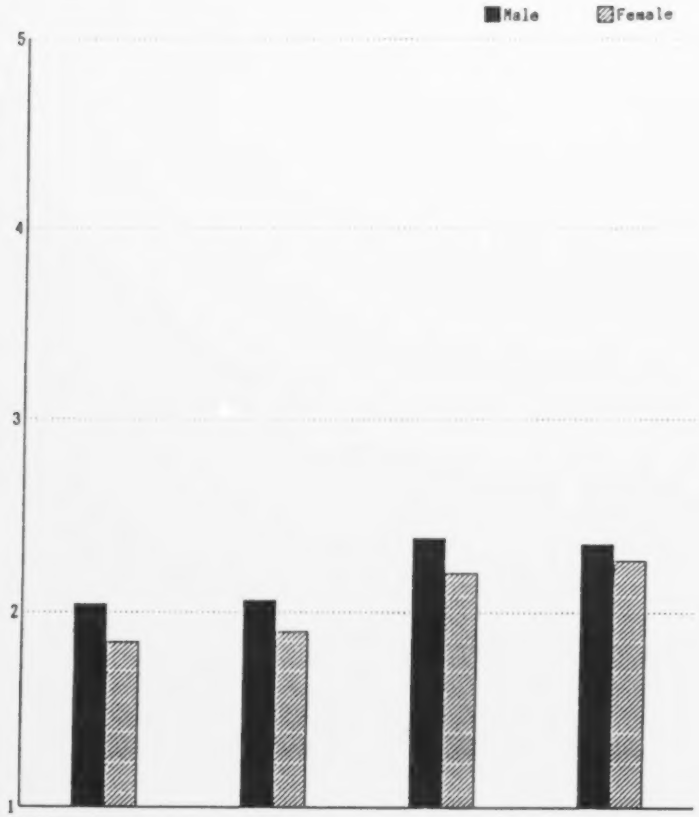


FIGURE 31

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES of experiences the students had on the different science activities out of the school.

The differences of the male and female students with regard to the frequency they have experienced various science activities outside their regular school hours were presented in Figure 32. It could be gleaned from the data that the male students seemingly stated that they acquired more experiences compared to the female students. It could be noted too that if the cut-off mean were to be centered at 2 or "rare", then all the male students fromthe different countries were able to acquire experiences above the scale. Both males and females from the students in the United States and the Philippines also acquired a mean higher than the "rare" calibration. The differences of the males and females with regard to the frequency of their activities related to science out of the school could probably be interpreted as the result of the innate spirit among the male groups to be more inclined to do exploratory activities. The males usually enjoy the challenge of nature, and therefore are inclined to indulge with the different science activities at a greater frequency. This male tendency is a common pattern in all the countries.

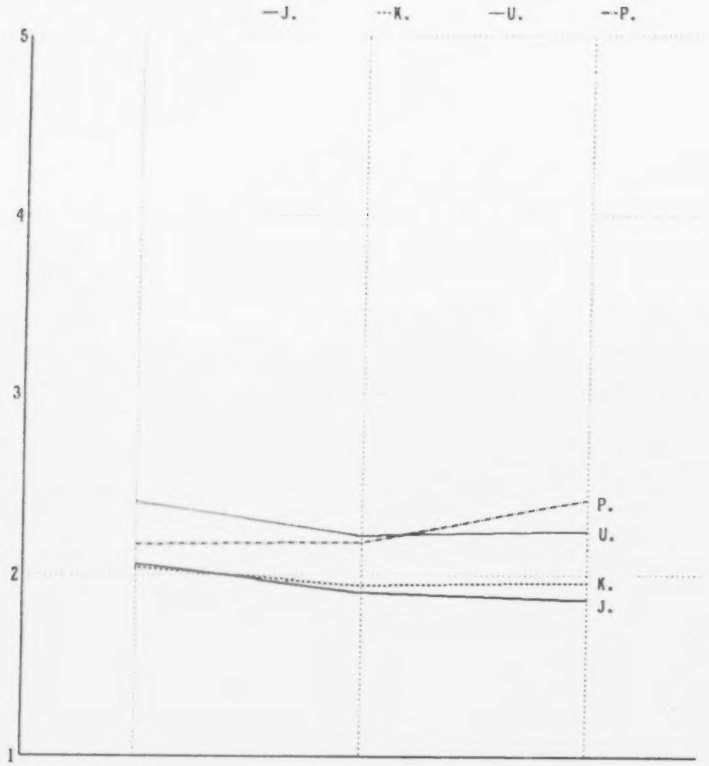
The data found in Figure 33 presented the mean of the students with regard to the different out-of-schoolscience experiences categorized according to the grade levels in which they belong to. As presented in the figure, the following trend can be observable. In Japan, the students seemed to show a declining tendency on their experiences related to science as



	J.	K.	U.	P.
Male	2.04	2.06	2.38	2.35
Female	1.85	1.90	2.20	2.27

FIGURE 32

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES, BY SEX



	7th	8th	9th
J.	2.06	1.91	1.87
K.	2.04	1.95	1.96
U.	2.40	2.22	2.24
P.	2.17	2.18	2.41

FIGURE 33

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES, BY GRADE they move to the higher grades of the educational ladder. On the other hand, the students from the Philippinnes posed a condition wherein they indulged on more activities as they advance in their educational experience. The students from the Republic of Korea and the United States seemingly possess similar pattern wherein a declining and an upward tendency has been illustrated by the mean ratings they acquired within the three-year period of their schooling. The Grade 8 students were therefore able to acquire the lowest mean when compared with the other two grade levels.

The varied patterns of the experiences in which the students from the countries involved in the study suggest that the school and other environmental factors within a certain country have strong influence over the chance to perform the different activities related to science. The countries actually are having a variety of socio-cultural environment, thus the experience of the students with regard to science could also be varied.

The out-of-school science experiences means and analysis of variance of the students from the four countries involved in their study according to sex and grade level were presented in Table 9. It could be noted from the data presented that the male students were able to acquire more experiences than the females which were considered as statistically significant. The experiences of the student were also found out to have mean differences dure to the grade level differences in which they belong. The data from the Philippines depicted thae fact that the mean ratings provided by the students in the higher grades were significantly more than those of the students at the lower

TABLE 9

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEANS AND ANALYSIS OF VARIANCE ACCORDING TO SEX AND GRADE

	JAPAN	KOREA	U. S. (a)	PHILIPPINES
Total Group	1. 94	1. 98	2. 28 (1. 64)	2. 31
Male	2. 04	2. 06	2. 38 (1. 69)	2. 35
Female	1. 85	1. 90	2. 20 (1. 60)	2. 27
Sex difference (df=1)	F=174. 59***	F=71. 67***	F=57. 60**	F=5. 96*
7th	2. 06	2. 04	2. 40 (1. 70)	2. 17
8th	1. 91	1. 95	2. 22 (1. 61)	2. 18
9th	1. 87	1. 96	2. 24 (1. 62)	2. 41
Grade difference (df=2)	F=65. 87***	F=7. 69***	F=22. 20**	F=19. 55***

(a) adjustment mean
(observed mean)

grades.

The out-of-school science experiences mean in all the items were shown in Table 10. The items included in the list were presented in the Sample Questionnaire found on page ____ of Chapter II. It could be noted from the data that some items were found out to be having the high mean values in all the countries involved in the study.

The out-of-school science experiences mean category by country in all the items were shown in Table 11. It could be noted that the experiences that acquired a rating higher or equal to a mean of 3 were "Have experience in caring for rabbits, cats, dogs, or hamsters (25)" for Japan. The data from the Republic of Korea suggest that "Have experience in using woodwork or metal work tools, e.g. pliers, saw, planes, screwdrivers, etc. (28)" acquired similar rating category. The items which were rated by the students from the United States that received the highest mean rating "Takes part in camping, fishing, or hiking (8)", "Have experience in caring for rabbits, cats, dogs, or hamsters (25)", and "Have experience in using woodwork or metal work tools, e.g. pliers, saw, planes, screwdrivers, etc. (28)". The items that received the highest main ratings in the Philippines were as follows:"Have experience in watching bird (9)", "Have experiences in gathering plants, leaves, and flowers (11)", "Watch TV science programs or listen to radio science programs (21)", "Have experience in caring for rabbits, cats, dogs, or hamsters (25)", and "Have experience in raising your favorite plants (29)". The different items that were rated to have ranks

TABLE 10

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN ALL ITEMS

	JAPAN	KOREA	U. S. (a)	PHILIPPINES
Total	1. 94	1. 98	2. 28 (1. 64)	2. 31
1	1. 94	2. 24	2. 16 (1. 58)	1. 93
2	2. 07	1. 38	1. 72 (1. 36)	1. 48
3	1. 84	1. 98	2. 80 (1. 90)	2. 87
4	2. 14	2. 03	1. 82 (1. 41)	1. 45
5	2. 12	2. 80	2. 74 (1. 87)	2. 31
6	1. 98	2. 24	1. 68 (1. 34)	2. 28
7	2. 42	1. 57	1. 26 (1. 13)	1. 50
8	2. 58	2. 50	3. 52 (2. 26)	2. 79
9	1. 45	1. 66	1. 84 (1. 42)	3. 18
10	1. 56	2. 15	1. 58 (1. 29)	2. 30
11	1. 68	2. 44	2. 32 (1. 66)	3. 34
12	1. 44	1. 64	2. 08 (1. 54)	2. 19
13	1. 62	1. 44	2. 08 (1. 54)	1. 74
14	2. 38	2. 58	2. 68 (1. 84)	1. 93
15	1. 73	1. 43	2. 66 (1. 83)	2. 91
16	1. 51	1. 46	1. 60 (1. 30)	1. 79
17	1. 63	1. 41	2. 68 (1. 84)	2. 30
18	1. 30	1. 48	1. 28 (1. 14)	1. 86
19	1. 25	1. 47	1. 46 (1. 23)	1. 59
20	1. 19	1. 64	2. 08 (1. 54)	2. 36
21	2. 46	2. 87	2. 60 (1. 80)	3. 38
22	2. 11	2. 15	2. 22 (1. 61)	1. 86
23	1. 38	1. 49	1. 96 (1. 48)	1. 80
24	1. 64	1. 34	2. 14 (1. 57)	1. 37
25	3. 19	2. 60	4. 04 (2. 52)	3. 47
26	2. 43	1. 84	2. 86 (1. 93)	2. 74
27	2. 13	2. 26	2. 32 (1. 66)	2. 07
28	2. 89	3. 39	3. 48 (2. 24)	2. 95
29	2. 29	1. 98	2. 56 (1. 78)	3. 60

(a) adjusted mean
(observed mean)

TABLE 11

OUT-OF-SCHOOL SCIENCE EXPERIENCE MEAN CATEGORY BY COUNTRY IN ALL ITEMS

	JAPAN	KOREA	U. S.	PHILIPPINES
Mean ≧ 3	25	28	8, 25, 28	9, 11, 21, 25, 29
3 > Mean ≧ 2	2, 4, 5, 7, 8, 14, 21, 22, 26, 27, 28, 29	1, 4, 5, 6, 8, 10, 11, 14, 21, 22, 25, 27	1, 3, 5, 11, 12, 13, 14, 15, 17, 20, 21, 22, 24, 26, 27, 29	3, 5, 6, 8, 10, 12, 15, 17, 20, 26, 27, 28

within the category higher than 2 but lesser than 3 were also presented in Table 11.

Looking closely at the data presented in Table 11, it would be possible to note that some items were categorized with ratings higher than 2 mean scores, which were considered common in all the countries concerned in the study. The items that were included in this category were: "Have experience in caring for rabbits, cats, dogs, or hamsters (25)", "Have experience in using woodwork or metal work tools, e.g. pliers, saw, planes,screwdrivers, etc. (28)", "Visits to the zoo (5)", and "Have experience in examining and repairing electrical appliances (27)".

B. MOTIVATION TOWARDS SCIENCE PROCESSES OF STUDENTS

The degree of motivation towards science processes was assessed by using an opinionnaire as shown in the Sample Opinionnaire of Motivation Towards Science as shown in page ____ of Chapter II. It could be noted from the opinionnaire that the scales calibration consisted of the following, to wit: Strongly Motivated, 5; Motivated, 4; Undecided, 3; Fairly Motivated, 2; and Not Motivated at All, 1.

The degree of motivation towards science processes mean in Japan, Republic of Korea, United States, and the Philippines were presented in Figure 34. It could be noted from the data, however, that the data represented only the countries with the available data, thereby leaving the space for the United States blank. It could be noted from the data, however, that the students from the

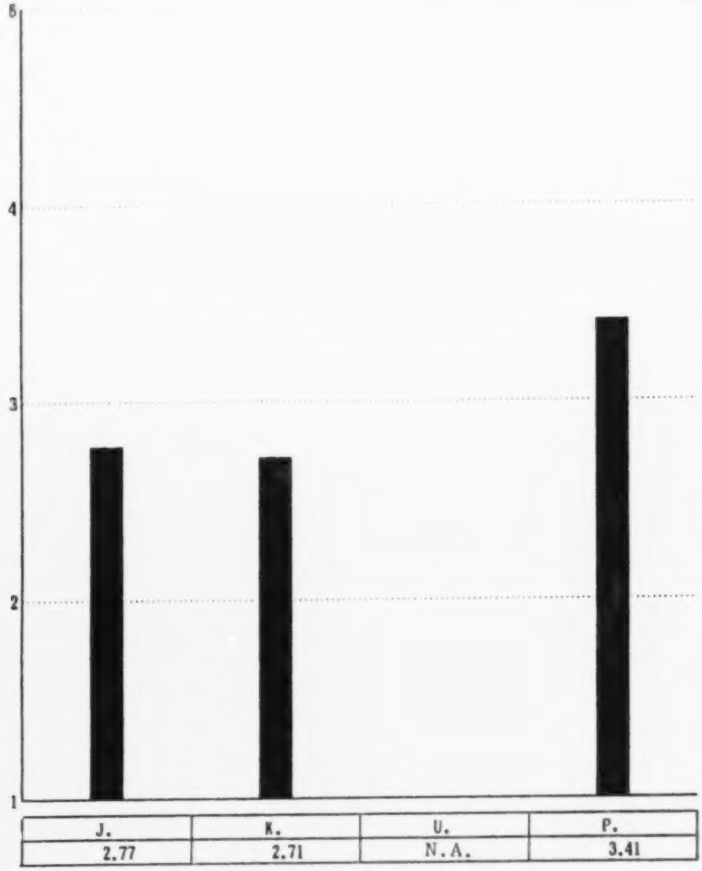


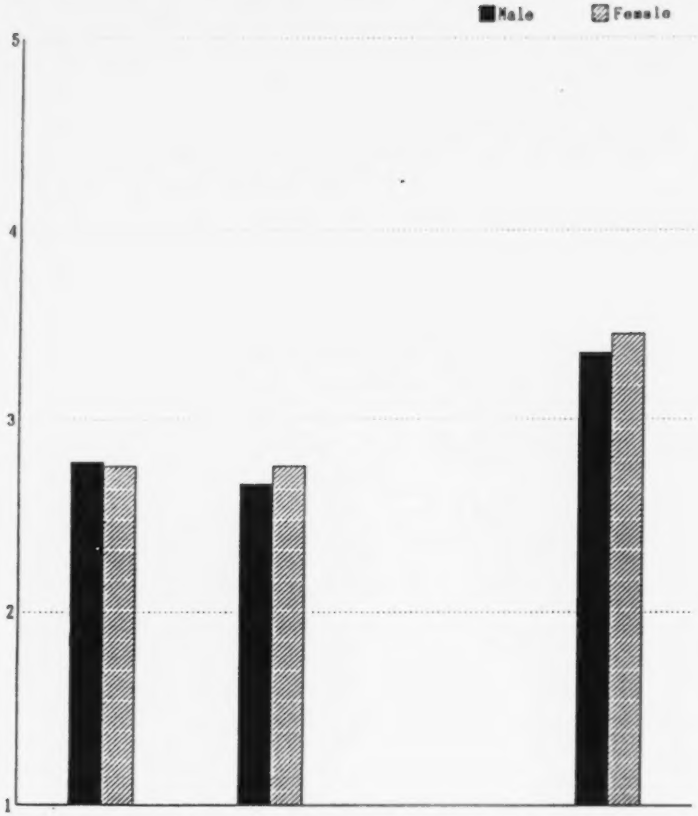
FIGURE 34

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES

Philippines seemingly had a positive mean value of 3.41. The data from Japan and Republic of Korea have been found out to possess a negative value from the mean if the midpoint is 3 since both countries acquired 2.77 and 2.71 mean ratings respectively.

The degree of motivation towards science process mean values in Japan, Republic of Korea, United States, and the Philippines according to sex of the student was presented in Figure 35. It could be noted from the data that the females rated their motivation towards science processes higher than the males when the data from Republic of Korea and the Philippines were to be analyzed. Although the male students seemed to have rated the degree of motivation towards science with a higher mean than the females, the mean differences was found out to be not significant. If the basis for the comparison of the ratings made by both sexes were the mean value of 3, then it could be stated that only the students, both males and females, were able to rate their degree of motivation towards science higher than that value. No commonalities among the countries, therefore, were found out among the ratings made by the students with regard to the motivation they felt towards science.

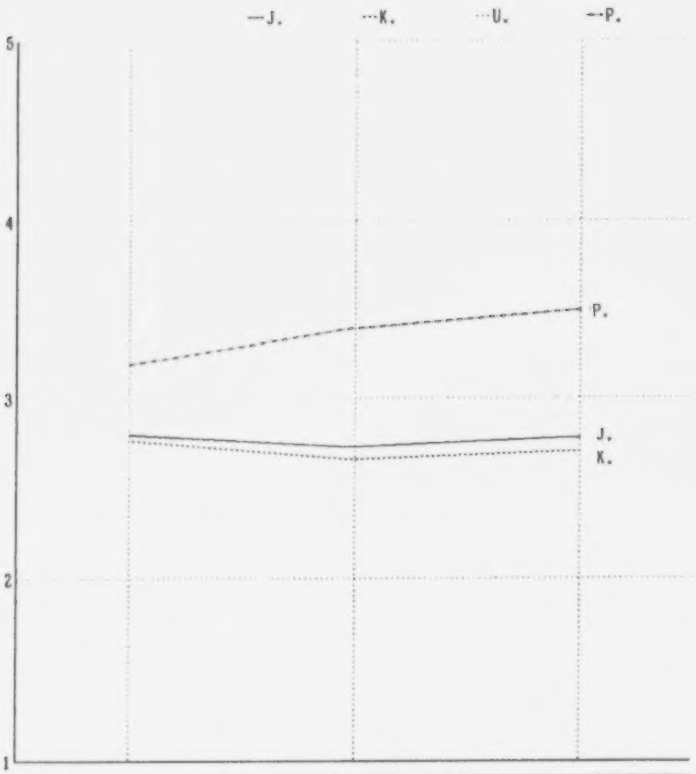
The grade levels of the students were also used as a basis to determine the type of motivation they possessed towards the science processes. It can be gleaned from Figure 36 that the data from all the countries suggest no commonality with regard to the pattern as the studentsrated the processes as on how motivated they were to deal with them. The data from Japan and Republic of Korea suggested that the ratings made by the second year students



	J.	K.	U.	P.
Male	2.78	2.66	N.A.	3.35
Female	2.76	2.76	N.A.	3.45

FIGURE 35

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY SEX



	7th	8th	9th
J.	2.80	2.73	2.78
K.	2.77	2.66	2.70
U.	N.A.	N.A.	N.A.
P.	3.19	3.39	3.49

FIGURE 36

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE were the lowest among the grade levels. The data from the Philippines showed an increasing positive degree of motivation as the students moved upward the educational ladder. The differences of the responses on the ratings made by the students seemingly was affected by the environmental condition of the students. As the students enter into the higher grade levels, based on the data from the Philippines, the science process become slightly interesting to the students because of the gradual change of the topics or subject matter which are geared towards the real life condition of the students as they move into the higher years.

The degree of motivation towards science processes of the students from the different countries seemingly have various types of patterns making the results inconclusive. The analysis of variance of the ratings made by the students according to sex was presented in Table 12. It could be noted from the data that the female students from the Republic of Korea acquired significantly higher mean ratings than the male students. This is also the same trend if the data from the Philippines were to be considered. However, there seems to be no significant difference of the ratings made by the malesand females in case of the students from Japan were concerned.

Furthermore, the data about the mean differences of the students based on the grade levels were also presented in Table 12. It could be deduced from the data that the students from the Philippines acquired significant differences on the ratings they had made as a result of their educational level. The students at the higher grade levels seemingly had rated their motivation

TABLE 12

MOTIVATION TOWARD SCIENCE PROCESSES MEAN AND ANALYSIS OF VARIANCE ACCORDING TO SEX AND GRADE

	JAPAN	KOREA	U. S.	PHILIPPINES
Total Group	2.77	2.71	(Not available)	3.41
Male	2.78	2.66		3.35
Female	2.76	2.76	(Not available)	3.45
Sex difference (df=1)	F=0.73NS	F=13.15•••		F=7.96••
7th	2.80	2.77		3.19
8th	2.73	2.66	(Not available)	3.39
9th	2.78	2.70		3.49
Grade difference (df=2)	F=3.15•	F=4.72•••		F=21.52•••

towards science processes significantly higher than those enrolled at the lower years. The data from the Republic of Korea also suggest the existence of a significant difference of the mean ratings made by the students on the motivation they felt on the different science processes, although the result does not necessarily favor those belonging to the higher grade levels since the students from Grade 7 had a higher accumulated mean more than those of the Grade 8 and Grade 9 students. The students from Japan also followed the pattern of the students from the Republic of Korea. The students from Japan and the Republic of Korea seemed to decline on their desire to perform the different science processes as they progress upwards of the educational ladder.

After analyzing the total ratings made by the students from the different countries involved in the study, as more detailed presentation of the items included on the science processes was made and presented in Table 13 and Table 14. It could be noted that based on the 15 items which pertains to the motivation towards science processes, the item that acquired mean ratings that is equal or above 3 included "Working patiently on an investigation until the time you can arrive at a solution (3)" and "Cooperating with other students (15)" if the students from Japan were to be considered. In the same basis of making a category, the students from the Republic of Korea were able to rate "Working patiently on an investigation until the time you can arrive at a solution (1)", Carrying out an investigationusing only the available facts (2)", "Predicting, hypothesizing,

TABLE 13

MOTIVATION TOWARD SCIENCE PROCESSES MEAN IN ALL ITEMS

	JAPAN	KOREA	U. S.	PHILIPPINES
Total	2.77	2.71		3.41
1	3.14	3.18		3.40
2	2.92	3.29		2.99
3	2.83	2.97		3.38
4	2.80	2.91		3.43
5	2.55	2.14		3.32
6	2.47	2.23		3.44
7	2.63	2.38	(Not available)	3.30
8	2.85	2.57		3.53
9	2.89	3.09		3.26
10	2.93	3.07		3.35
11	2.66	2.34		3.41
12	2.60	2.63		3.25
13	2.55	2.70		3.13
14	2.37	2.22		3.53
15	3.35	2.89		4.39

TABLE 14

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN CATEGORY BY COUNTRY IN ALL ITEMS

	JAPAN	KOREA	U. S.	PHILIPPINES
Mean ≧ 3 (Positive)	1, 15	1, 2, 9, 10	(Not avairable)	all except item 2

inferring, etc. (9)", and "Recording data (10)". The students from the Philippines were able to rate all the items, except item 2, with a mark not lesser than mean rating 3. The item 2 refers to "Carrying out an investigeston using only available facts".

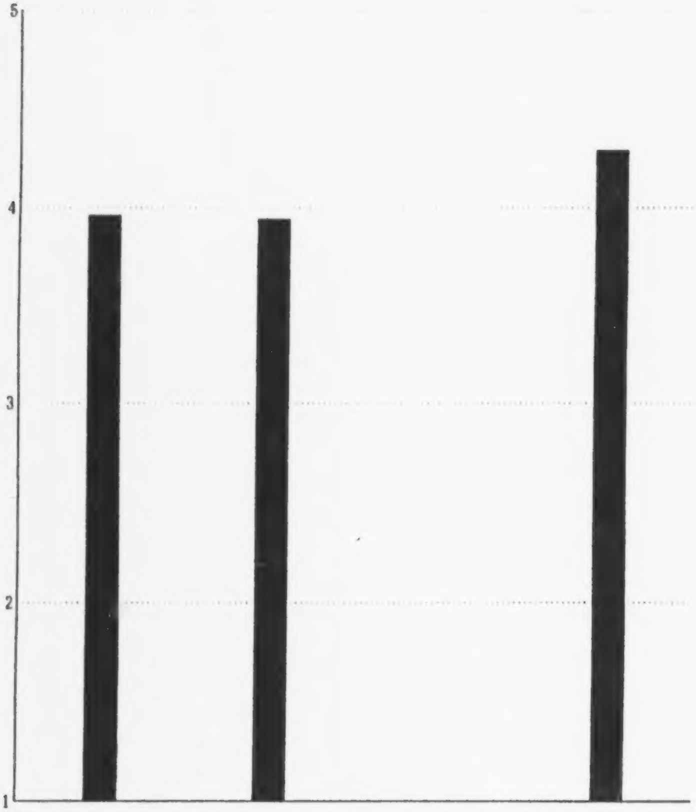
It could be considered that a positive motivation of the students is an important factor that should not be taken for granted within a science classroom if a teacher desires the student to properly manage doing the different science processes. A learner should not be considered a problem unless the frequency and intensity of his reactions to science processes interfere with effective understanding or enjoyment of the normal interaction occuring within a science class. This condition of having a good motivation towards the different science processes is apparent among the learners of the secondary schools, who are characterized to be in their adolescent years, as this period is marked by great activity when energy and exuberance are expressed and where action and feeling constitute the best types of appeal.

C. LOVE TOWARDS NATURE OF THE STUDENTS

The degree of emotion that the subjects included in the study possess were also analyzed in this section after measuring their emotional stature towards nature using a five-point Likert scale instrument. The emotional aspect of the study dealt on the "Beauty of Nature", "Respect for Life", "Love of Nature", and Greatness of Nature". The term emotion can be considered to be in the affective domain. It was stated by Cafer (1972) that emotion can probably be aroused by anything that gratifies or further's a person's needs or desires. As the learner grows older and enter the period of adolescence, there is a complicated interplay between their emotion, their motives, and their hopes and probably their future plans. This would certainly affect the learner's view towards nature.

The degree of emotion, that is love for nature, of the students from the countries involved in this study was presented in Figure 37 by means of showing the mean ratings made by the students in all the items of the love for nature scale. Prior to the actual interpretation of the data, the calibration utilized in the scale should first be defined. The five scales found on the figure followed this scale description which are shown as follows: Strongly Feel It, 5; Feel It, 4; Undecided, 3: Fairly Feel It, 2; and Feel Nothing, 1. If the data from the countries - Japan, Republic of Korea, and the Philippines were to be analyzed, then it would be possible to state that all the students were able to rate all the emotional feelings of loving nature positively since the ratings were all very close to 4, that is "Feel It" in the scale utilized in this study.

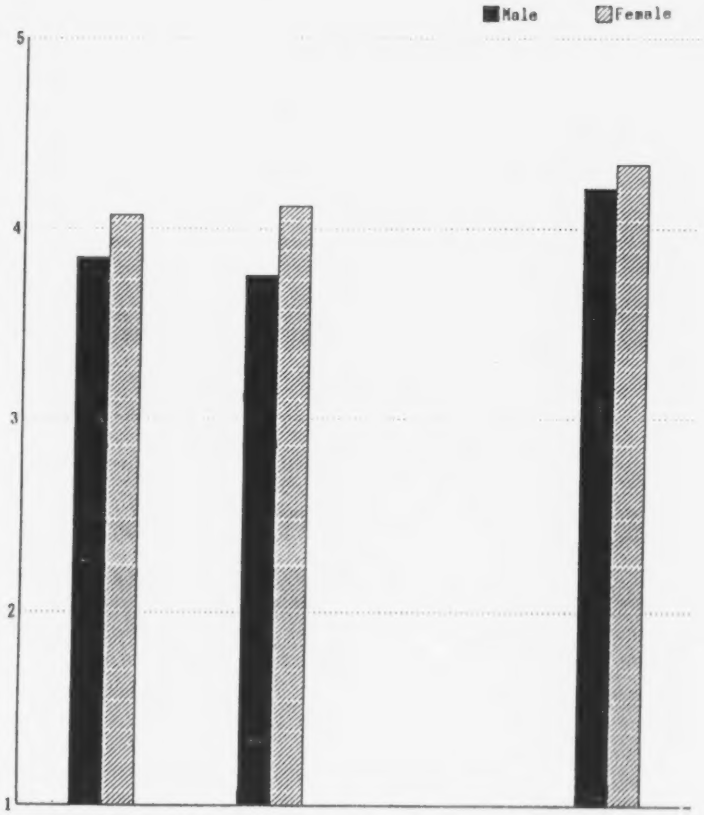
The total means of the students from Japan, Republic of Korea, and the Philippines as to the love of nature they possessed were in Figure 38. It could be noted that the common trend among the countries with the data on love for nature in that females possessed higher mean than the males. It could also be noted, that the female group in each of the countries were able to rate their love for nature with a mean value that is more than 4.0 of the scale.



J.	K.	U.	P.
3.96	3.94	N.A.	4.29

FIGURE 37

LOVE FOR NATURE MEAN IN JAPAN,
SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES



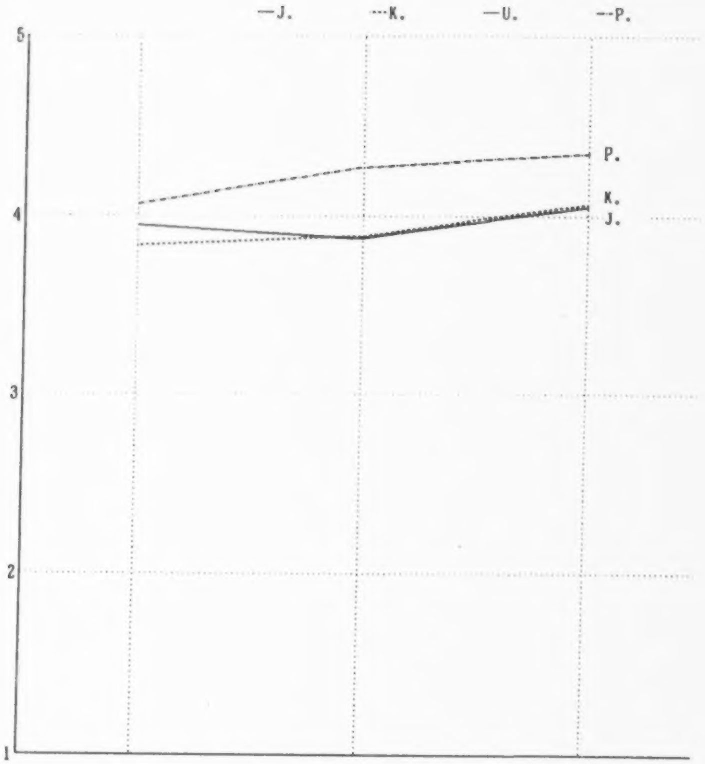
	J.	K.	U.	P.
Male	3.85	3.75	N.A.	4.21
Female	4.07	4.12	N.A.	4.34

FIGURE 38

LOVE FOR NATURE MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES, BY SEX

The ratings made by the students from the three countries on the degree of their feeling towards loving nature by grade levels were also presented in Figure 39. It could be noted from the data that the students from the Philippines and Republic of Korea were able to increase the ratings they have provided to to each of the items of the love of nature scale commensurate to their grade levels. Students in the higher grades were able to rate their love for nature higher than the students who belong to the lower grades. Although the data from the Philippines and Republic of Korea seemingly followed a similar tendency, the students from the Philippines were able to rate the scales a little higher if the cut-off rating to be used were 4.0 scale. It can easily be gleaned from the figure that the students from Japan rated the love for nature scales in unstable manner because the Grade 8 students made the lowest rating when compared with the other grade levels.

As presented in Table 15, the students from Japan, Philippines, and Republic of Korea seemingly acquired significant differences on the mean ratings they have provided the feeling towards nature that they possess. The data showed that a significant difference existed among the sexes with regard to their love for nature. It could therefore be concluded that the female students in the three countries acquired mean values that were significantly higher than the male students. A significant difference on the ratings provided by the students by grade levels was calculated from the data acquired. The higher grade students from the and Republic of Korea seemingly were able to



	7th	8th	9th
J.	3.95	3.88	4.05
K.	3.84	3.89	4.07
U.	N.A.	N.A.	N.A.
P.	4.07	4.28	4.35

FIGURE 39

LOVE FOR NATURE MEAN IN JAPAN,
SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES, BY GRADE

TABLE 15

LOVE FOR NATURE MEAN AND ANALYSIS OF VARIANCE BY SEX AND GRADE

	JAPAN	KOREA	U. S.	PHILIPPINES
Total Group	3.96	3.94	(Not available)	4.29
Male	3.85	3.75		4.21
Female	4.07	4.12	(Not available)	4.34
Sex difference (df=1)	F=87.68•••	F=118.13•••		F=11.65•••
7th	3.95	3.84		4.07
8th	3.88	3.89	(Not available)	4.28
9th	4.05	4.07		4.35
Grade difference (df=2)	F=16.82•••	F=16.45•••		F=16.67•••

TABLE 16

LOVE FOR NATURE MEAN IN ALL ITEMS

	JAPAN	KOREA	U. S.	PHILIPPINES
Total	3.96	3.94	(Not available)	4.29
1	3.98	3.96		4.15
2	3.86	3.82		4.09
3	3.98	4.32		4.45
4	4.00	3.64		4.45

TABLE 17

LOVE FOR NATURE MEAN CATEGORY BY COUNTRY IN ALL ITEMS

	JAPAN	KOREA	U. S.	PHILIPPINES
Mean ≧ 3 (Positive)	1, 2, 3, 4	1, 2, 3, 4	(Not avairable)	1, 2, 3, 4,

have rated their love for nature significantly higher than those of the lower grade students. The tendency, however, was found out to be inconclusive if the data from Japan were used because of the declining tendency of the mean ratings provided by the students at Grade 8, thus providing a mean rating lower than the next lower and higher grade levels.

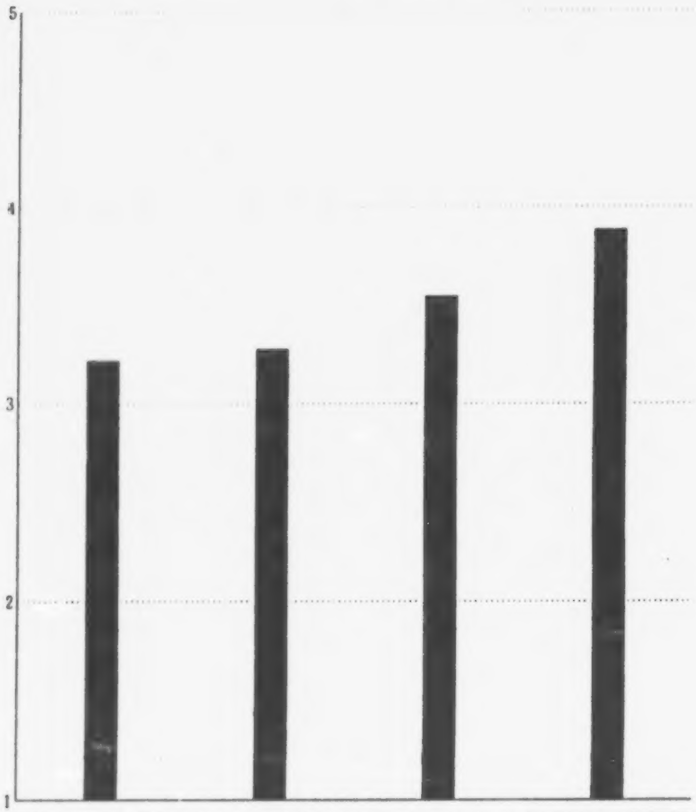
In order to clarify the seemingly inconclusive status of the tendency patterns on the love for nature of the students based on the mean ratings according to grade levels, the data presented in Table 16 and 17 are worth considering. It could be noted from Table 17 that the students from the three countries were able to acquire mean ratings of their love for nature which were categorized to be more than 3. It can therefore be stated that although the students from the different countries were exposed to various types of environmental conditions, the feelings that the students possess towards natrue can be considered similar. The personal feeling towards nature can be observable as common to all the students. This can be interpreted as the result of the innate tendency of man to love nature.

D. ATTITUDE TOWARDS SCIENCE LESSONS OF THE STUDENTS

Educators must not only provide for the adequate mental development of the learners but also must make provisions for their proper attitude. It can be stated that attitude of students towards science subjects may be considered important if teachers wish to maximize the learning capability that the students possess. It was stated by Bloom (1976) that three important variables determine the great percentage of variety in the school learning process of the learners. He stated further that 25% of the variation of the learners achievement in school can be traced on the affective setting that they possess. It was also stated that attitude of the students correlated higher with science achievement when compared with the result in the other areas. It was stated by Simpson (1978) that: "It becomes evident that the amount of learning that takes place in a science classroom relates positively to the initial interest and attitudes brought to the class by the students. This relationship moreover, seems to be cumulative, suggesting that prior learning experiences in a subject area influence future learning experiences in that area and that attitude and achievement tend to become more closely related as students get older."

The attitude towards science of the students were measured by using a 20-item Likert scale. The calibration made to represent the scales were as follows: Strongly Agree, 5; Agree, 4; Undecided, 3; Disagree, 2; and Strongly Disagree, 1.

The attitude towards science lesson mean in Japan, Republic of Korea, United States, and the Philippines were presented in Figure 40. It could be noted that the students from all the countries were able to provide ratings which accumulated a mean value higher than 3 of the scale. The highest mean value among the countries were that of the Philippines which has 3.89. The data from the other countries were slightly lower with regard to the mean ratings the students have given to their attitude towards science lessons.



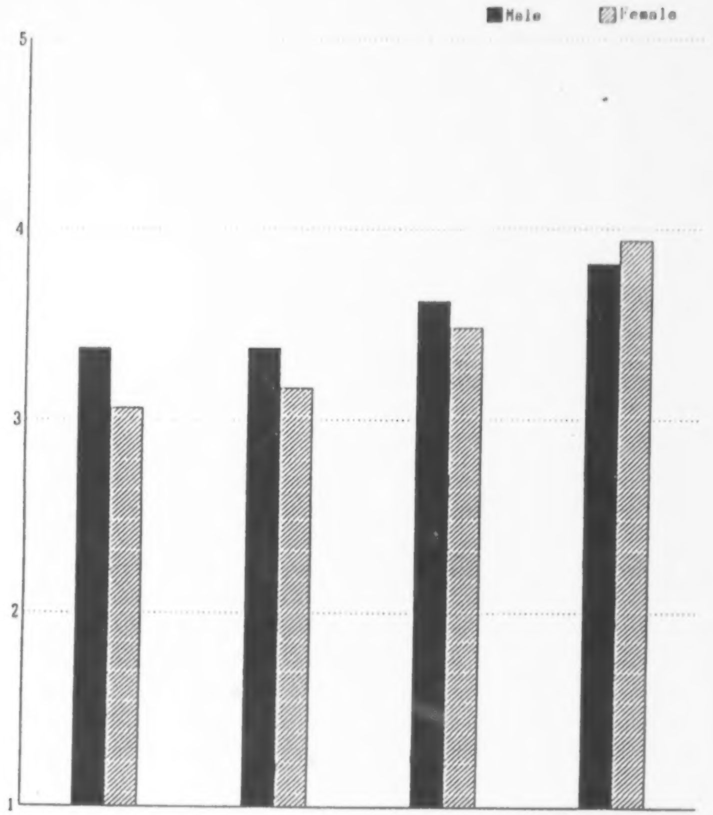
J.	K.	U.	P.
3.22	3.28	3.55	3.89

FIGURE 40

ATTITUDE TOWARDS SCIENCE LESSONS MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES

The attitude towards science lessons mean in the countries involved in the study by sex was presented in Figure 41. It could be noted from the data presented that the male students from Japan, Republic of Korea, and the United States were able to acquire higher mean ratings than the female students. The students from the Philippines, however, posed a different trend thereby presenting the female students to have rated their attitude towards science higher than that of the male students. The males getting a higher rating on the attitude related to science can not therefore be considered as a common trend in all the countries concerned in this study. Thhe condition of inconclusiveness can be traced from the differences of instruction being offered in the different classroom settings. The variety on the teaching procedures being employed by the teachers could provide differences on the attitude towards science lessons in both males and females. Science teachers should therefore consider the role of sex differences in the acquisition of the appropriate attitude.

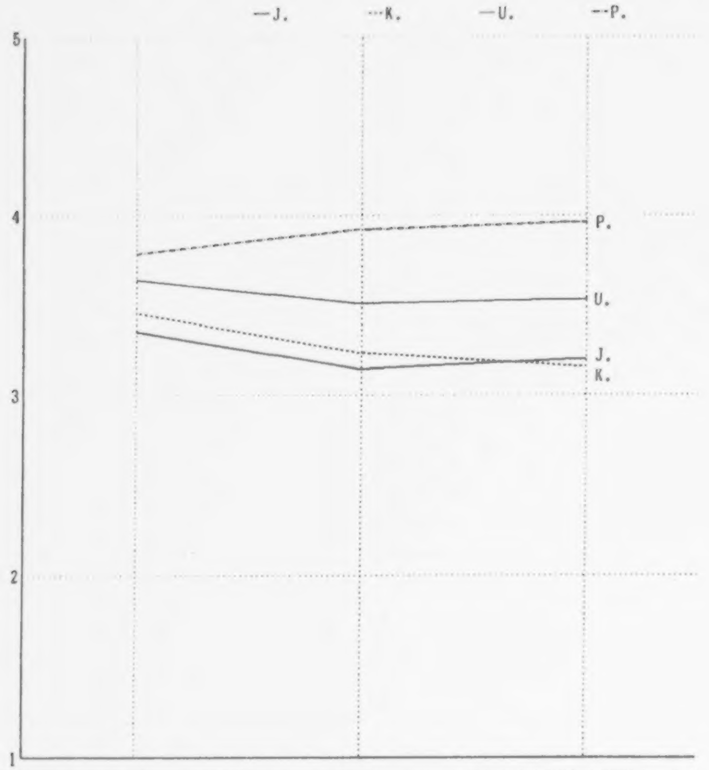
The attitude towards science lessons mean values in Japan, Republic of Korea, United States and the Philippines by grade level were presented in Figure 42. It has been projected on the figure that various patterns can be observable from the countries as to the attitude towards science lessons of the students concerned. It can be noted that the students from the REpublic of Korea seemed to have lost their positive attitude towards science lesson as aa result of their having moved to the higher levels of the school system. On the contrary, the students from the



	J.	K.	U.	P.
Male	3.38	3.38	3.63	3.82
Female	3.06	3.17	3.49	3.94

FIGURE 41

ATTITUDE TOWARDS SCIENCE LESSONS MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY SEX



	7th	8th	9th
J.	3.35	3.14	3.19
K.	3.45	3.23	3.15
U.	3.64	3.50	3.52
P.	3.78	3.92	3.96

FIGURE 42

ATTITUDE TOWARDS SCIENCE LESSONS MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE

Philippines provided a sign of positive improvement in their attitude towards science as an effect of their having reached the higher grade levels. The data from the United States and Japan exemplified a similar tendency of the students. The students from these countries seemed to have demonstrated declining attitude as they enter Grade 8, which is comparatively lower than that of Grade 7, and the later required a change of attitude during the time they have reached Grade 9. This condition could probably be explained by the fact that the four countries involved in this study utilized different kinds of school curricula. The variety of curricula these countries possess may have directly affected the inconclusive condition of the findings in all the countries about the attitude towards science lessons.

The analysis of variance on the mean scores garnered by the students from the four countries by sex and by grade were presented in Table 18. The data suggest that differences on the mean were significant based on the responses made by students. So in the Philippines, it could be stated that the female students were able to acquire attitudes towards science which is considered to be significantly higher than the males. On the other hand, the male students acquired significantly higher mean than the females on attitude towards science lessons when the ratings concerned were that of the students from Japan, Republic of Korea, and the United States. With regard to the effect of grade level on the attitude towards science lessons mean, it could be deduced from the data that the existence of the significant difference exist in all the countries.

TABLE 18

ATTITUDE TOWARDS SCIENCE LESSONS MEAN AND ANALYSIS OF VARIANCE BY SEX AND GRADE

	JAPAN	KOREA	U. S.	PHILIPPINES
Total Group	3.22	3.28	3.55	3.89
Male	3.38	3.38	3.63	3.82
Female	3.06	3.17	3.49	3.94
Sex difference (df=1)	F=237.44•••	F=61.89•••	F=18.04•••	F=18.25•••
7th	3.35	3.45	3.64	3.78
8th	3.14	3.23	3.50	3.92
9th	3.19	3.15	3.52	3.96
Grade difference	F=39.42•••	F=47.66•••	F=6.35••	F=7.76•••

•:$p<0.05$
••:$p<0.01$
•••:$p<0.001$

E. INTERCORRELATION AMONG SELECTED VARIABLES RELATED TO SCIENCE EDUCATION

The different variables related to science education that were included in this section of the study were out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons. The data on the intercorrelation of these variables were presented in Table 19. Based on the data presented, the different variables can be interprested to have been positively correlated to each other.

It would be worthwhile to take note that Table 19 presented data maintaining the correlation of the variables only within each country. The data from Japan suggest that the out-of-school science experiences of the students were highly correlated with that of the motivation towards science process that the students possess. That trend is also true when the data used is from the Republic of Korea and the Philippines. The least correlated variable to the out-of-school experience of the learners, however, was the love for nature in the three countries. The only available data from the United States within the intercorrelation was that of out-of-school science experiences and attitude towards science lessons which had been found to have a positive correlation.

The data from Table 19 also depicted the intercorrelation values between the motivation towards science processes and the love for nature and attitude towards science lessons. It is very clear from the data that the motivation in which the students possessed correlated highly to the love foe nature more than that

TABLE 19

CORRELATION COEFFICIENT MATRIX AMONG SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, LOVE FOR NATURE, AND ATTITUDE TOWARD SCIENCE LESSONS

		Experience	Motivation	Love	Attitude
Science Experience	J		.47***	.27***	.37***
	K		.56***	.28***	.28***
	U		(NA)	(NA)	.22***
	P		.35***	.15***	.28***
Motivation toward Science Process	J			.42***	.43***
	K			.44***	.34***
	U			(NA)	(NA)
	P			.37***	.33***
Love for Nature	J				.20***
	K				.14***
	U				(NA)
	P				.35***
Attitude toward Science Lessons	J				
	K				
	U				
	P				

(NA):not available

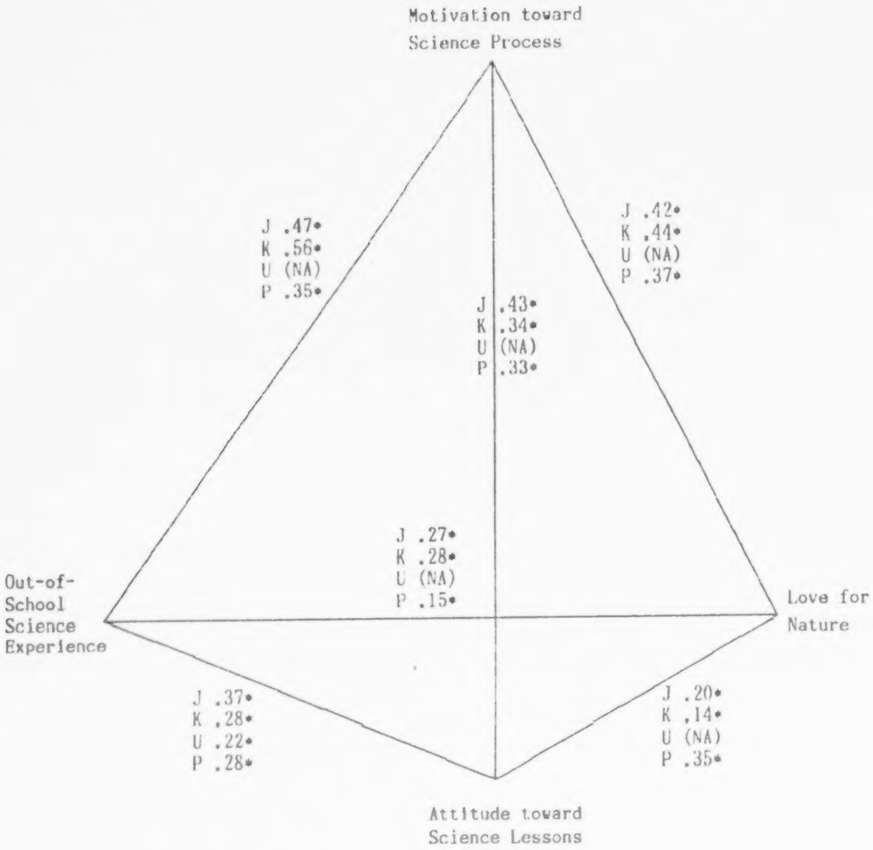

Motivation toward Science Process
J .47*
K .56*
U (NA)
P .35*
J .42*
K .44*
U (NA)
P .37*
J .43*
K .34*
U (NA)
P .33*
J .27*
K .28*
U (NA)
P .15*
Out-of-School Science Experience
Love for Nature
J .37*
K .28*
U .22*
P .28*
J .20*
K .14*
U (NA)
P .35*
Attitude toward Science Lessons

FIGURE 43

SUMMARY DIAGRAM OF CORRELATION ANALYSIS AMONG SELECTED VARIABLES of attitude toward science lessons if the bases were the responses from the students of Japan and the Republic of Korea. The condition showed a reversible condition, attitude correlated better with the motivation more than that of love for nature, when the data used is the one taken from the Philippines.

The data from Table 19 further presented the fact that love for nature is also positively correlated to the attitude of the students towards science lessons.

The interrelationships among the different variables as mentioned above, can be shown in a summary digram form as depicted on Figure 43. It could be noted from the data presented that a positive correlationexist among the variables such as out-of-school science experiences and attitude towards science lessons, a condition that could be interpreted to have existed naturally within the students experiences. The high positive correlation can be observable between motivation towards science processes, love for nature, and out-of-school science experiences. The low positive correlation, however, can be observed between out-of-school science experiences and love for nature.

Concluding Remarks

Out-of-school science experience and love for nature, based on the data gathered, seem to be exemplifying significant differences as caused by the sex of the learners. The male students seemingly possess more experiences in science while out of the school. The females, however, exemplifies more affection towards nature than the males. This condition is common in all the countries.

It was however found out, based on the data, that the motivation towards science processes and attitude towards science lessons can be stated as inconclusive in terms of whether there are commonalites among the four countries. This could be explained by the fact that the learners used in the study were having four different natural and socio-cultural exposures as a result of their coming from four different countries.

The aforementioned condition could be explained by the fact that although the subjects were from four nations, therefore they can be classified into four races, the sex difference towards out-of-school science experiences and love for nature can be stated to be a commonality among the four countries' samples. The significant differences on the factors, might have been caused by the effect of inborn capacities of the males to be dealing with more challenging science experiences and therefore learn to love nature more than the females.

The other explanations for the noted sex differences in terms of out-of-school science experiences and love for nature, as exemplified to be common in the 4 countries, can be traced from the influence of educational factor and parental expectations. However, these conditions do not exist in terms of the variable srelated to the motivation towards science processes and attitude towards science lessons when the sex differences were determined in the 4 countries. There is the inconclusive condition among the countries whether sex differences exist regarding their attitude and motivation patterns are concerned. It could therefore be an argument that if the parents expect their children to have positive tendency in the attitude and motivation factors, then commonality on sex difference might be concluded in the countries involved. Our data do not support the commonality pattern of sex difference of students in the countries. It could therefore be stated that the factors "Motivation Towards Science Processes" and "attitude Towards Science Lesson" might have been the direct result of classroom instructional procedures utilized in the science courses.

In terms of the grade level difference, it has been clear from the data presented that no common pattern can be seen that could incorporate all the ratings made by the students by country. This condition of inconclusiveness on the pattern acquired by the students csn be traced on the differences of the curricular offerings being utilized in the countries involved in the study. The socio-cultural environment can also be traced to be providing a reason for the existence of the diferences of pattern on how the students have rated the various variables such as out-of-school science experiences, motivation towards science lessons, and love for nature, based on the grade levels. It was observable that in some countries like the Philippines, the students' ratings on these science variables increased as their educational level goes higher. On the other hand, the data from Japan, United States, and Republic of Korea showed the unstable pattern on the ratings the students have made about the various science variables as the effect of the grade level they have enrolled in.

III. THE RELATIONSHIP OF THE VARIOUS CHARACTERISTICS OF STUDENTS TO THE SCIENTIFIC THINKING SKILLS IN SCIENCE

The interrelationships of the different characteristics possessed by the students from Japan, Republic of Korea, United States, and the Philippines were determined at this section of the study. The different characteristics of the students, as was stated earlier, included the out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons.

A. The Relationship of the Out-of-School Experiences and the Scientific Thinking Skills

The commonalities among the countries with regards to the relationship of the out-of-school experiences and the scientific thinking skills of the students were categorized whether they were, common items in all countries, common items in most countries, or inconclusive items.

The analysis made pertaining to the relationship of the out-of-school science experiences and the scientific thinking skills were presented in Table 20 and Table 21. The items presented in these tables depicted the experiences that were considered common in the different countries involved in this study.

The relationship of the out-of-school science experiences and the reasoning skills of the students were specifically presented in Table 20. As presented in the table, the items that

TABLE 20

OUT-OF-SCHOOL SCIENCE EXPERIENCES RELATED TO GALT COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (4 out of 4)	1, 27, 28	23
Common Item in Most of the Countries: (3 out of 4)	4, 5, 6, 7, 8, 15, 17, 18, 19, 21, 24	3, 9, 10, 13, 14, 16, 22, 26, 29
Inconclusive (2 to 2)	2, 11, 12, 20, 25	

TABLE 21

OUT-OF-SCHOOL SCIENCE EXPERIENCES RELATED TO TIPS COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (4 out of 4)	1, 17, 21	16, 23
Common Item in Most of the Countries: (3 out of 4)	2, 3, 5, 6, 7, 8, 12, 18, 19, 20, 24, 25, 27	9, 11, 14, 15, 26
Inconclusive (2 to 2)	4, 10, 13, 22, 28, 29	

significantly related to the reasoning skills were "Visits to science museums, science centers (1)", "Have experience in examining and repairing electrical appliances (27)", and "Have experience in using woodwork or metal work tools, e.g. pliers, saw, planes, screwdrivers, etc.." The inconclusive items included are "Visits to planetariums (2)", "Have experience in gathering plants, leaves, and flowers (11)", "Have experience in gathering rocks and fossils (12)", "Participate in boy or girl scouting (20)", and "Have experience in caring for rabbits, cata, dogs, or hamsters".

The relationship of the out-of-school science experiences and the science process skills of the students were presented in Table 21. The items that significantly related to the science process skills included "Visits to science museums, science centers (1)", "Visit geological places, e.g. strata, volcanoes, and seashores (17)", and "Watch TV science programs or listen to radio science programs (21)". The items that were considered as inconclusive among the countries included "Visits to marine science centers (4)", "Have experience in insect collecting (10)", "Observe stars and moon through telescope (13)", "Have experience in using microscopes (22)", "Have experience in using woodwork or metal work tools, e.g. pliers, saw, planes, screwdrivers, etc..(28)", and "Have experience in raising your favorite plants (29)".

Based on the data from Table 20 and Table 21, thw out-of-school science experiences items that significantly related to both reasoning and process skills common to all countries included only the "Visits to science museums, science centers". The item that has no significant relation to the scientific thinking skills and which is considered a commonality among the four countries was "Have experience in making scientific experiments with your own instruments". The item that we considered common in most countries, three out of four countries, included "Visits to the zoo (5)", "Visits to botanical gardens (6)", "Receives private tutoring in science and/or mathematics (7)", "Takes part in camping, fishing, or hiking (8)", "Takes part in science club activities (18)", and "Participate in special activities of science centers or museums (19)".

B. The Relationship Between Motivation Towards Science Processes And Scientific Thinking Skills

The commonalities among the countries involved in the study, with the exception of the United States because of the lack of data on this aspect, on thhe relationship of motivation towards science processes and the scientific tjinking skills were presented in Table 22 and Table 23. The common items as presented in the two tables included those that were common in all countries, and those that were common in most of the countries.

The relationship between motivation towards science processes and reasoning skills of the students that were considered common among the countries can be found in Table 22. The items that were considered common in three countries - Japan, Republic of Korea, and the Philippines were "Working patiently on an investigation until the time can arrive at a solution (1)".

TABLE 22

MOTIVATION TOWARDS SCIENCE PROCESSES RELATED TO GALT COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (3 out of 3)	1, 2, 3, 4, 9, 12	14
Common Item in Most of the Countries: (2 out of 3)	5, 6, 8, 10	7, 11, 13, 15

TABLE 23

MOTIVATION TOWARDS SCIENCE PROCESSES RELATED TO TIPS COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (3 out of 3)	1, 2, 3, 4, 5, 9	10, 11
Common Item in Most of the Countries: (2 out of 3)	6, 7, 8	12, 13, 14, 15

"Carrying out an investigation using only the available facts (2)", "Devising a new method of observing and experimenting (3)", "Thinking logically and critically (4)", "Predicting, hypothesizing, inferring, etc.(9)", and "Interpreting data (12)". These items were considered to be common in most of the countries; to wit: "Getting involved in data collecting (5)", "Getting involved in finding problems from the environment (6)", "Testing new ideas (8)", and "Recording data (10)". On the contrary, the item "Applying findings to new problems" posed no significant relation at all with the reasoning skills in all the countries.

The motivation towards science processes items that are related to the science process skills of students in Japan, Republic of Korea, and the Philippines can be seen in Table 23. The items that related to the science process skills in all the three countries were "Working patiently on an investigation until the time you can arrive at a solution (1)", "Carrying out an investigation using only the available facts (2)", "Devising a new method of observing and experimenting (3)", "Thinking logically and critically (4)", "Getting involved in data collection (5)", and "Predicting, hypothesizing, inferring, etc.. (9)". Items such as "Getting involved in finding problem from the environment (6)", "Sorting and classifying national objects (7)", and "Testing new ideas" were found out to significantly relate to the process skills considered to be a commonality in two out of three countries. The items that did not have a significant relationship to the science process skills in all the countries were "Recording data (10)" and "Analyzing data (11)".

Looking carefully at the data in Table 22 and Table 23, it would be possible to note that the motivation towards science processes items that significantly related with the science process skills and the reasoning skills included "Working patiently on an investigation until the time you can arrive at a solution (1)", "Carrying out an investigation using only the available facts (2)", "Devisiong a new method of observing and experimenting (3)", "Thinking logically (4)", and "Predicting, hypothesizing, inferring, etc..(9)". These items seemingly were the tasks that can be utilized in understanding the GALT and TIPS subscales used in this study.

C. The Relationship of the Love for Nature and Scientific Thinking Skills

The relationship of love of nature items and scientific thinking skills have been presented in Table 24 and Table 25 using only the data from the three countries, namely Japan, Republic of Korea, and the Philippines. The classification of the relationships calculated has therefore been made into their being common in all the countries, and in most of the countries.

As shown in Table 24, the love for nature items significantly related with the reasoning skills of the students common to all the countries were as follows: "Beauty of Nature (1)" and "Greatness of Nature (2)". The "Love for Nature (4)" has been considered to be possessing the significant relationship to the reasoning skills in most of the countries.

TABLE 24

LOVE FOR NATURE RELATED TO GALT COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (3 out of 3)	1, 2	----------
Common Item in Most of the Countries: (2 out of 3)	4,	3

TABLE 25

LOVE FOR NATURE RELATED TO TIPS COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (3 out of 3)	1, 2	---------
Common Item in Most of the Countries: (2 out of 2)	4	3

The data presented in Table 25 suggest that the love for nature items that significantly related to the science process skills of the learners in all the countries were the same as those that related to the reasoning skills. It could be noted, however, that the data failed to present an item that related significantly to the science process skills which is common in all the countries.

It can also be noted from the data presented in Table 24 and Table 25 that not any of the itmes in the love for nature has been found out to be a commonality among the countries as to the relationship to the reasoning and science process skills is concerned.

D. The Relationship of Attitude Towards Science Lessons and Scientific Thinking Skills

The data available in Table 27 and Table 28 included those from the four countries - Japan, Republic of Korea, United States, and the Philippines. The classification of the commonalities existing among the countries were made into three categories, namely: (a) common items in all countries, (b) common items in most countries, and (c) inconclusive.

The relationships of the attitude towards science lessons items and the reasoning skills were presented in Table 26. The common items in all the countries that possessed significant relationship to the reasoning skills were as follows: "I am always under a terrible strain in a science class (1)" and "My mind goes blank and I am unable to think clearly when working in

TABLE 26

ATTITUDE TOWARDS SCIENCE LESSONS RELATED TO GALT COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (4 out of 4)	1, 6	10
Common Item in Most of the Countries: (3 out of 4)	2, 3, 4, 7, 8 13, 15, 18	5, 11, 12, 16, 17 19, 20
Inconclusive (2 to 2)	9, 14	

TABLE 27

ATTITUDE TOWARDS SCIENCE LESSONS RELATED TO TIPS COMMON TO ALL COUNTRIES

	Significant Relation	Not Significant Relation
Common Item in All Countries: (4 out of 4)	1, 3, 4, 6, 18	10
Common Item in Most of the Countries: (3 out of 4)	2, 7, 8, 13, 15, 17	5, 11, 16, 19, 20
Inconclusive (2 to 2)	9, 12, 14	

science (6)". The items that were considered to be common in most of the countries as having significant realtionship to the reasoning skills were "I do not loke science and it scares me to have to take it (2)", "Science is very interesting to me and I enjoy science courses (3)", "Science is fascinating and fun (4)", "I feel a sense of insecurity when attempting science (7)", "Science makes me feel uncomfortable, restless, irritable, and impatient (8)", "I approach science with a feeling of hesitation resulting from fear of not being able to do science (13)", "Science is a course in school which I have always enjoyed studying (15)", and "I am happier in a science class than in any other class (14)". The items that were considered as inconclusive amont the countries were "The feeling that I have towards science is a good feeling (9)", and "I really like science (14)".

The relationship of the attitude towards science lesson items and the process skills were presented in Table 28. The common items in all the countries that possessed significant relationship to the science process skills were as follows: "I am always under a terrible strain in a science class (1)", "Science is very interesting to me and I enjoy science courses (3)", "Science is fascinating and fun (4)", "My mind goes blank and I am unable to think clearly when working in science (6)", and "I am happier in a science class than in any other class (18)". The items that were considered common items that possessed significant relationship with the science process skills were !I do not like science and it scares me to have to take it (2)", "I feel a sense of insecurity when attempting science (7)", "Science makes me feel uncomfortable, restless, irritable, and impatient (8)", "I approach science with a feeling of hesitation resulting from a fear of not being able to do science (13)", "Science is a course in school which I have always enjoyed studying (15)", and "I have nevernliked science and it is my most dreaded subject". The items such as "The feeling that I have towards science is a good feeling (9)", "When I hear the word science, I have a feeling of dislike (12)", and "I really like science (14)" were considered to be inconclusive among the four countries.

The attitude towards science lessons items that possessed significant relationships to both reasoning and process skills in all the countries included "I am always under a terrible strain in a science class (1)", and "My mind goes blank and I am unable to think clearly when working in science (6)".

E. The Relationship and Correlation of the Scientific Thinking Skills and the Various Characteristics of the Students

The relationship and correlation of the reasoning and science process skills to the various characteristics of the students such as out-of-school science experiences, motivation towards science science processes, love fro nature and attitude towards science lessons were analyzed in this section of the studey. The specific correlation coefficients as well as the analysis of various values were calculated by presenting the total of all skills, in both reasoning and process skills, and the different subscales. The subscales of the reasoning skills that were correlated with the characteristics of students were conservation, proportional reasoning, controlling variables, probabilistic reasoning, correlational reasoning, and the combinatorial reasoning. In the same manner, the significant relationships as well as correlation of the following science process subscales, i.e., stating hypotheses, identifying variables, operationally defining, designing investigations, and graphing data, to the different characteristics possessed by the students were also calculated.

The relationship of the reasoning subscales to the variables such as out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons were presented in Table 28. Based on the total GALT Score, the data presented suggest that all the student characteristics in the countries involved in the study were all having the significant relationship. All the characteristics also found out to be significantly related to the conservation proportional, and combinatorial reasoning subscales as stipulated on the data from all the countries.

The correlation coefficient result between reasoning subscales and factors such as out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons of the students by countries were presented in Table 29. It can be noted from the data that the GALT total highly correlated to motivation and attitude of the students as shown in that portion for Japan. Motivation also possessed a higher correlation to the GALT total compared to the other factors if the data from the Republic of Korea were to be

TABLE 28

ANALYSIS OF VARIANCE MATRIX OF GALT SUBSCALES AND FACTORS SUCH AS OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, LOVE FOR NATURE, AND ATTITUDE TOWARDS SCIENCE LESSONS

	JAPAN				KOREA				U. S.				PHILIPPINES			
	E df=116	M df=60	L df=16	A df=80	E df=116	M df=60	L df=16	A df=80	E df=58	M	L	A df=80	E df=116	M df=60	L df=16	A df=80
GALT Total	** 5.03	** 11.80	** 13.60	** 7.38	** 3.93	** 5.34	** 4.73	** 2.68	** 9.78			** 3.05	** 2.53	** 3.38	** 5.80	** 3.77
G 1 : Conservation	** 3.56	** 5.14	** 4.92	** 4.08	** 1.90	* 1.35	* 1.83	** 1.66	** 6.19			** 2.00	** 2.09	** 2.35	** 5.84	** 3.05
G 2 : Proportional Reasoning	** 3.26	** 7.78	** 9.39	** 4.70	** 2.64	** 3.30	** 2.90	** 1.92	** 4.26			** 1.63	** 1.72	** 2.12	** 2.76	** 1.78
G3 : Controlling Variebles	** 3.66	** 7.21	** 11.70	** 4.76	** 2.55	** 3.38	** 4.01	** 2.12	** 5.09	Not available		** 1.98	NS 1.23	** 2.20	* 1.72	* 1.31
G 4 : Probabilistic Reasoning	** 2.76	** 5.72	** 5.60	** 3.84	** 2.45	** 3.60	** 2.83	** 1.53	** 4.28			** 1.63	NS 1.04	NS 1.32	NS 1.03	NS 1.18
G 5 : Correlational Reasoning	NS 1.09	** 1.51	* 1.74	** 1.61	NS 1.05	NS 0.77	NS 1.22	NS 1.11	** 1.58			NS 1.04	NS 0.98	** 1.52	NS 1.33	** 1.70
G 6 : Combinatorial Reasoning	** 2.10	** 2.64	** 3.06	** 2.04	** 2.15	** 2.48	** 2.97	** 1.54	** 3.52			** 1.92	** 1.92	** 2.53	** 2.78	** 2.75

E : Science Experience Out of School
M : Motivation toward Science Processes
L : Love for Nature
A : Attitude toward Science Lessons

TABLE 29

CORRELATION COEFFICIENT MATRIX BETWEEN GALT SUBSCALES AND FACTORS SUCH AS OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, LOVE FOR NATURE, AND ATTITUDE TOWARDS SCIENCE LESSONS

	JAPAN				KOREA				U. S.				PHILIPPINES			
	E	M	L	A	E	M	L	A	E	M	L	A	E	M	L	A
GALT Total	*** .08	*** .28	*** .16	*** .22	*** .16	*** .25	*** .11	*** .15	*** .14			*** .13	*** .19	*** .17	*** .18	*** .25
G 1 : Conservation	*** .11	*** .17	*** .09	*** .19	*** .10	*** .11	NS .01	*** .09	*** .15			*** .12	*** .13	*** .14	*** .18	*** .23
G 2 : Proportional Reasoning	*** .07	*** .23	*** .11	*** .17	*** .13	*** .19	*** .08	*** .14	*** .11			*** .08	*** .16	*** .15	*** .12	*** .15
G 3 : Controlling Variebles	*** .05	*** .24	*** .16	*** .16	*** .08	*** .19	*** .09	*** .12	*** .09	Not available		*** .09	*** .10	*** .09	NS .05	*** .10
G 4 : Probabilistic Reasoning	** .04	*** .19	*** .10	*** .13	*** .10	*** .16	*** .06	*** .09	*** .09			*** .08	NS .00	NS .03	NS .00	NS .02
G 5 : Correlational Reasoning	NS .02	*** .05	* .03	*** .07	NS .04	NS .01	NS .02	NS -.01	NS .04			NS .03	** -.08	NS -.03	NS -.02	** -.08
G 6 : Combinatorial Reasoning	NS .00	*** .12	*** .08	*** .08	*** .07	*** .16	*** .10	** .05	* .05			*** .08	*** .13	** .07	*** .12	*** .17

E : Science Experience Out of School
M : Motivation toward Science Processes
L : Love for Nature
A : Attitude toward Science Lessons

analyzed. Among the factors, it could be stated that the attitude of the students from the Philippines significantly correlated the most to the GALT total value. With regards to the subscales, the conservation reasoning skill of the students from the Philippines possessed a positive correlation with the attitude that they have, higher than those of the other factors. Using the data from Japan, it could be noted that the motivation towards science processes acquired a higher positive correlation to the proportional and controlling variables of the reasoning skills. These correlations were considered high because they acquired a correlation coefficient value higher than 0.20. The other correlation values, although they show positive correlation between the reasoning subscales and the various factors on the characteristics of the students, simply depicted values lower than r = 0.20. It could be stated that from the data presented, commonalities of trend among the countries was not possible to delineate. It couls however be stated that motivation and attitude of students tend to correlate significantly with the reasoning skills higher than those of the other student characteristics. Attitude and motivation factors might be interpreted to be directly affected by the instructional procedures being used in schools, and so these can be interprested to be affecting the acquisition of acceptable cognitive skill of the learners.

The analysis of variance of the TIPS total and subscales performance of the students from the countries involved in the study as to the effect of the various factors related to the characteristics of students were presented in Table 30. It has been presented on the data that all the characteristics, such as out-of-school science experience, motivation towards science processes, love for nature, and attitude towards science lessons were found to possess significant relationship to the science process skills in all the countries. This condition could be interpreted as a positive sign of the possibility of improving the capacity of the students to deal with the different science process skills by enhancing their acquisition of the different characteristics utilized in this study. Being able to provide the students with ample out-of-school science experiences, such as those discussed in this study, would surely help a lot in improving success of students in performing various process skills in science. It would then be necessary for the teachers to encourage students to acquire positive motivation towards science processes, love for nature, and attitude towards science lessons so that better understanding of the process skills in science could be attained by the students.

The correlation coefficient values calculated using the TIPS total and subscales, and factors such as out-of-school science experiences, motivation towards science lessons by countries were presented inTable 31. The correlation coefficients that were equal or more than 0.20 can be used to show a high significant correlation of the performance of the students on the TIPS total and subscales to the different cahracteristics of the students. It could be noted from the data that in Japan and Korea a commonality could be observed because both motivations towards

TABLE 30

ANALYSIS OF VARIANCE MATRIX OF TIPS SUBSCALES AND FACTORS SUCH AS OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, LOVE FOR NATURE, AND ATTITUDE TOWARDS SCIENCE LESSONS

	JAPAN				KOREA				U. S.				PHILIPPINES			
	E df=116	M df=60	L df=16	A df=80	E df=116	M df=60	L df=16	A df=80	E df=58	M	L	A df=80	E df=116	M df=60	L df=16	A df=80
TIPS Total	•• 6.59	•• 15.69	•• 21.90	•• 9.74	•• 4.31	•• 7.35	•• 6.10	•• 3.42	•• 10.29	Not available		•• 3.07	•• 3.36	•• 5.97	•• 8.14	•• 6.58
T 1 : Stating Hypotheses	•• 5.21	•• 9.20	•• 12.80	•• 6.80	•• 3.61	•• 4.69	•• 2.93	•• 2.94	•• 7.25			•• 2.42	•• 2.01	•• 3.54	•• 6.07	•• 4.03
T 2 : Identifying Variables	•• 4.47	•• 10.69	•• 15.18	•• 6.00	•• 2.97	•• 5.49	•• 6.83	•• 2.41	•• 3.78			•• 1.45	•• 1.89	•• 2.70	•• 2.65	•• 2.60
T 3 : Operationally Defining	•• 4.10	•• 9.50	•• 14.33	•• 6.38	•• 2.55	•• 3.52	•• 3.23	•• 2.12	•• 6.61			•• 2.23	•• 2.17	•• 4.07	•• 4.44	•• 3.44
T 4 : Designing Investigation	•• 3.57	•• 7.63	•• 10.25	•• 4.84	•• 2.22	•• 3.73	•• 3.90	•• 2.81	•• 6.17			•• 2.55	•• 1.65	•• 1.82	•• 3.05	•• 1.93
T 5 : Graphing Data	•• 3.86	•• 8.57	•• 12.48	•• 5.48	•• 3.03	•• 4.79	•• 3.71	•• 2.45	•• 6.31			•• 2.60	•• 1.76	•• 3.98	•• 4.91	•• 3.49

E : Science Experience Out of School
M : Motivation toward Science Processes
L : Love for Nature
A : Attitude toward Science Lessons

TABLE 31

CORRELATION COEFFICIENT MATRIX BETWEEN TIPS SUBSCALES AND FACTORS SUCH AS OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, LOVE FOR NATURE, AND ATTITUDE TOWARDS SCIENCE LESSONS

	JAPAN				KOREA				U. S.				PHILIPPINES			
	E	M	L	A	E	M	L	A	E	M	L	A	E	M	L	A
TIPS Total	*** .10	*** .35	*** .22	*** .25	*** .18	*** .31	*** .15	*** .21	*** .15	Not available		*** .12	*** .21	*** .24	*** .25	*** .34
T 1 : Stating Hypotheses	*** .09	*** .27	*** .18	*** .20	*** .13	*** .23	*** .09	*** .19	*** .12			*** .12	*** .16	*** .19	*** .21	*** .28
T 2 : Identifying Variables	*** .07	*** .29	*** .19	*** .19	*** .15	*** .28	*** .16	*** .16	** .06			NS .04	*** .18	*** .14	*** .14	*** .20
T 3 : Operationally Defining	*** .09	*** .26	*** .18	*** .21	*** .13	*** .19	*** .09	*** .15	*** .13			*** .09	*** .10	*** .17	*** .18	*** .23
T 4 : Designing Investigation	*** .06	*** .25	*** .16	*** .17	*** .11	*** .21	*** .11	*** .15	*** .13			*** .12	** .10	*** .10	*** .11	*** .14
T 5 : Graphing Data	*** .07	*** .26	*** .16	*** .19	*** .16	*** .26	*** .11	*** .16	*** .15			*** .11	*** .12	*** .18	*** .18	*** .24

E : Science Experience Out of School
M : Motivation toward Science Processes
L : Love for Nature
A : Attitude toward Science Lessons

science process correlated highly to the TIPS total and subscales. The attitude towards science lessons has also been observed as a common pattern of the students from the Philippines and Japanbecause most of the subscales fo the process skills in science correlated highly on it. To be specific, the subscale that correlated highly to the attitude of the students in the Philippines were stating hypothesis, identifying variables, operationally defining, and graphing data. Stating hypothesis and operationally defining correlated highly with the attitude towards science lessons of the students from Japan. Based on these results, it could be stated that motivation and attitude also correlated with the process skills just as with the reasoning skills.

Concluding Remarks

The summary diagram of the correlation analysis and multiple analysis of variance concerning the scientific thinking skills and selected variables such as out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons were presented in Figure 44.

The correlation analysis results seemed to project the fact that variables such as motivation towards science processes and attitude towards science lessons relatively tend to possess more significant relationship to reasoning skills and science process skills when compared to the correlation coefficient values acquired between the two scientific thinking skills and variables such as out-of-school science experiences and love for nature.

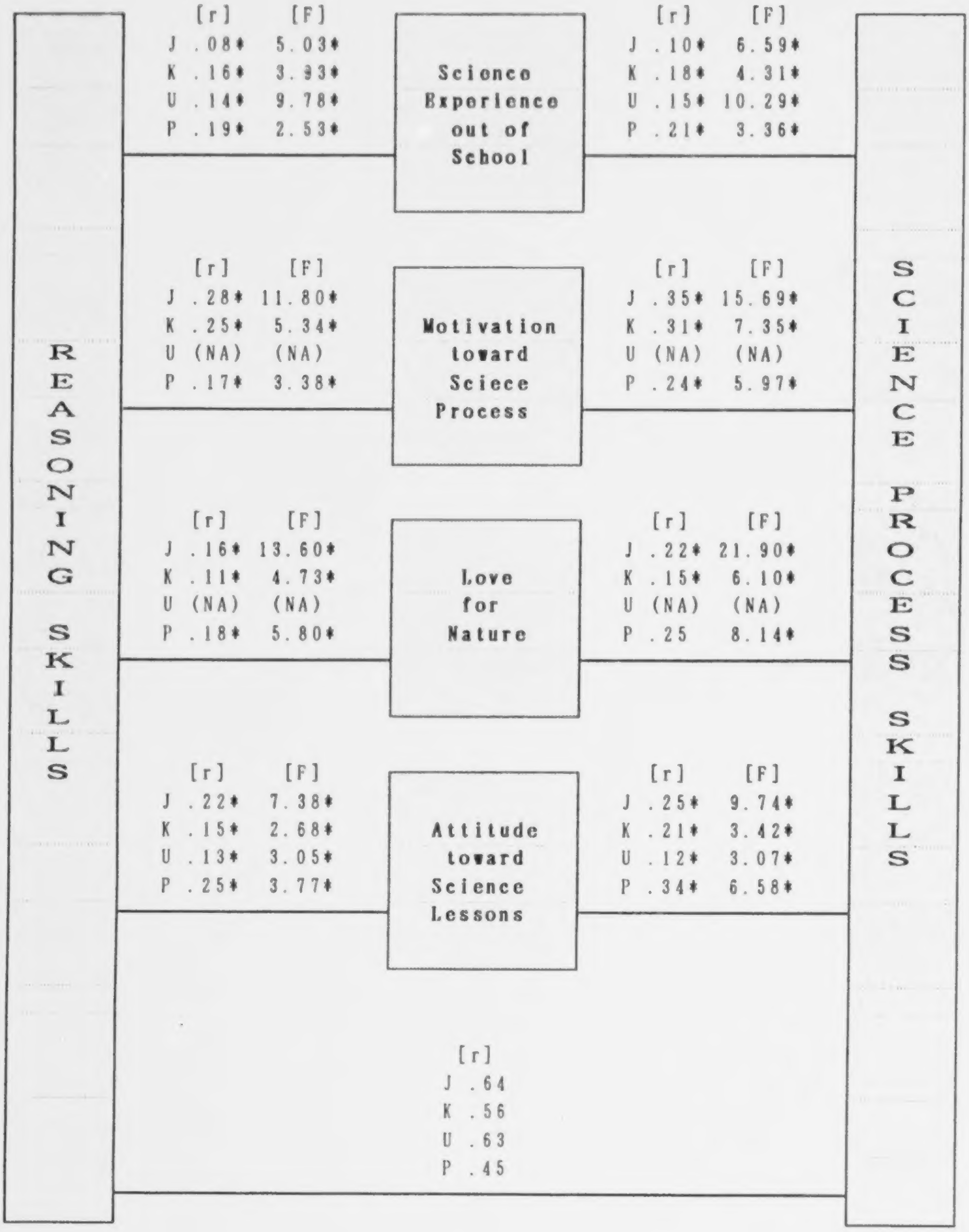

REASONING SKILLS
SCIENCE PROCESS SKILLS
[r] [F]
J .08* 5.03*
K .16* 3.93*
U .14* 9.78*
P .19* 2.53*
Science Experience out of School
[r] [F]
J .10* 6.59*
K .18* 4.31*
U .15* 10.29*
P .21* 3.36*
[r] [F]
J .28* 11.80*
K .25* 5.34*
U (NA) (NA)
P .17* 3.38*
Motivation toward Sciece Process
[r] [F]
J .35* 15.69*
K .31* 7.35*
U (NA) (NA)
P .24* 5.97*
[r] [F]
J .16* 13.60*
K .11* 4.73*
U (NA) (NA)
P .18* 5.80*
Love for Nature
[r] [F]
J .22* 21.90*
K .15* 6.10*
U (NA) (NA)
P .25 8.14*
[r] [F]
J .22* 7.38*
K .15* 2.68*
U .13* 3.05*
P .25* 3.77*
Attitude toward Science Lessons
[r] [F]
J .25* 9.74*
K .21* 3.42*
U .12* 3.07*
P .34* 6.58*
[r]
J .64
K .56
U .63
P .45

FIGURE 44

SUMMARY DIAGRAM OF CORRELATION ANALYSIS AND MULTIPLE ANALYSIS OF VARIANCE CONCERNING THINKING SKILLS AND SELECTED VARIABLES

Both scientific thinking skills, reasoning and process skills, however were found out to possess a positive correlation to all the variables related to the characteristics possessed by the secondary school students from Japan, Republic of Korea, United States, and the Philippines. The reasoning skills and science process skills were also found out to possess significant relationship with the different variables mentioned.

If the subscales of the reasoning and science process skills were to be interpreted closely, it would be possible to conclude that the students performance in these two skill suggest that all the science process subscales tend to correlate significantly to all the variable related to the characteristics of the students, but not all of the subscales of the reasoning skills correlated to the same variables. The fact that the process skills subscales all significantly correlated to the student characteristics variables suggest that this condition as a common tendency of the performance attained by the students in the countries involved in the study.

A high significant correlation between the reasoning skills and the science process skills has also been found out in all the countries. Based on the results, it would be possible to state that the variables such as the motivation towards science process and attitude towards science lessons possess more significant correlation to the science process skills compared to the correlation that exist between these skills and the variables such as love for nature and out of school science experiences. The fact that both motivation towards science process and attitude towards science lessons can be afffected directly by science instructional procedured being undertaken in the classroom would enable teachers to improve the capability of the learners to perform various process skills activities within the classroom setting by improving these characteristics on them. Through the utilization of appropriate science instructional procedures, it would be possible to improve the motivation towards science processes and attitude towards science lessons of the learners. Allowing this to happen would naturally increase the dexterity of the learners to perform the different process skills in science such as stating hypothesis, identifying variables, defining operationally, designing investigations, and graphing and interpreting data. Being able to develop on the students the capability to deal with the process skills in science would inevitably allow the acquisition of the cognitive capacity to deal with the reasoning skills which included conservation, proportion, controlling varaibles, probability, correlation, and combination. It would therefore be possible to foster the development of the reasoning skills of the learners through the science instructional procedures that emphasize the effectiveness of using the different science process skills. The appropriate motivation and attitude that the learners possess certainly can have a positive effect on the capability of the learners to deal with the scientific thinking skills.

Chapter IV

THE SCIENTIFIC THINKING SKILLS OF SOME ELEMENTARY SCHOOL PUPILS IN JAPAN

At the time this study was undertaken, it can be stated that at the elementary school level in Japan the science courses are taught to the learners as separate subjects in all the grades, from Grade One to Grade Six. The content of the science subjects included topics categorized into "Living Things and Their Environment", "Matter and Energy", and "The Earth and the Universe". Through the different activities in science the teachers in Japan attempt to develop among the learners the scientific thinking skills necessary in understanding the various concepts in this field.

The teachers in Japan commonly adhere to guidelines for special consideration in teaching science throughout the period of the elementary school as stated in the "Course of Study" for science. It was stated in the "Course of Study for Elementary Elementary Schools in Japan" that:

> "1. For the teaching of the lower grades, consideration should be paid to helping pupils group the characteristics of nature through such activities as observing, searching for, raising and producing various things, in nature, and also enhancing the effectiveness of teaching especially in relation to various activities concerning language, arithmetic, and handicraft.

2. For the guidance of observations, experiments, cultivation of plants, raising of animals and reproduction, attention should be paid to the prevention of accidents.
3. For the teaching about living things, weather, river, rock strata, etc., it is necessary to take pupils outside the school, to get in close contact with the regional nature, and to help develop an interest in the preservation of nature." (Ministry of Education, Science and Culture of Japan, 1983).

Due to the important value of the observation and experimentation process being stressed by teachers of science at the elementary school levels in Japan, it is expected that learners could be able to deal satisfactorily with the different scientific thinking skills required in understanding the various knowledge and concepts in science. This section of the research, therefore, has emphasized the performance of the elementary grade pupils, specifically those enrolled at the Grade 5 and Grade 6 levels on the different scientific thinking skills. The different characteristics that the pupils possess as a result of their out-of-school science experience, motivation towards science processes, love for nature, and attitude towards science lessons were also analyzed by means of determining their relationship and effect on their performance in the reasoning and process skills. The mean ratings the pupils provided each of the different characteristic factors were also presented in this section.

For the sake of determining the performance effectiveness of

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the pupils from Japan, a set of data that was gathered from the United States was also presented at the discussion of the process skills section of this study. The instrument that was used to measure the process skills possessed by the students in the United and Japan was the Performance of Process Skills (POPS) Test which has been designed for the grade levels of the Grade 5 and Grade 6 pupils as was mentioned earlier in the first chapter of this study.

A. THE REASONING AND SCIENCE PROCESS SKILLS OF THE PUPILS

The reasoning skills, process skills in science, and the relationship and correlation between the two types of skills are considered as important topics that must be known to the teachers in order to improve the learning and teaching process inside a science classroom. The effect of sex difference and grade level on the capability to perform the various scientific thinking skills must also be understood by the teachers in order to foster their effectiveness in teaching science courses.

1. Reasoning Skills of Pupils in Japan

The percentage of students who were able to correctly answer all the revised reasoning subscales, as measured by the revised GALT, in Japan according to sex was shown in Figure 45. It could be gleaned from the data that the percentage of pupils who were able to get the correct responses of the reasoning skills in total comprised only 29.9%. Out of this percentage, the number of

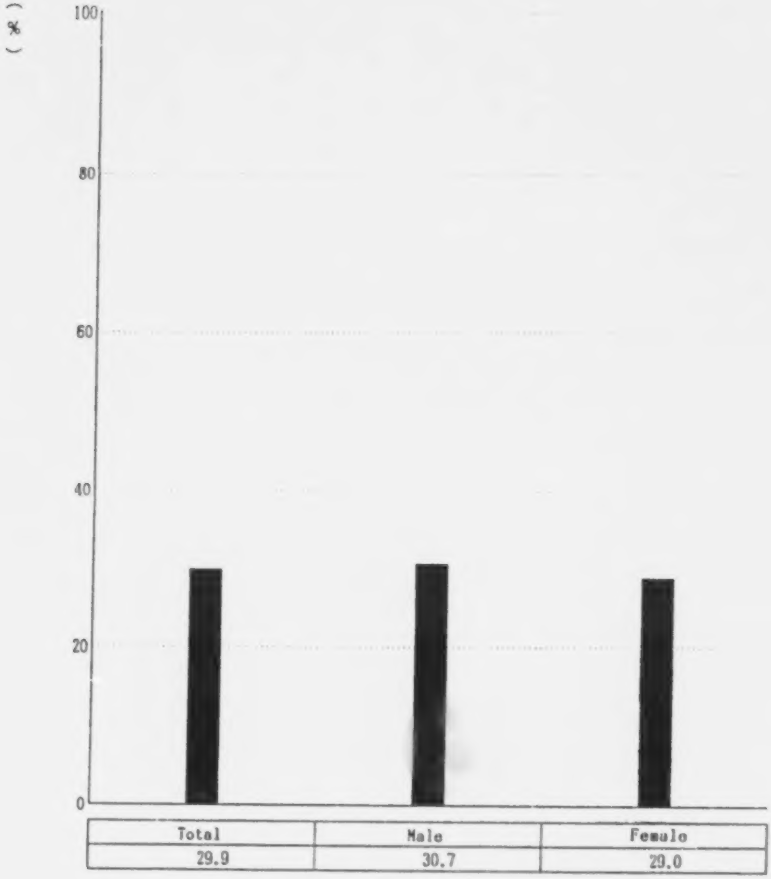
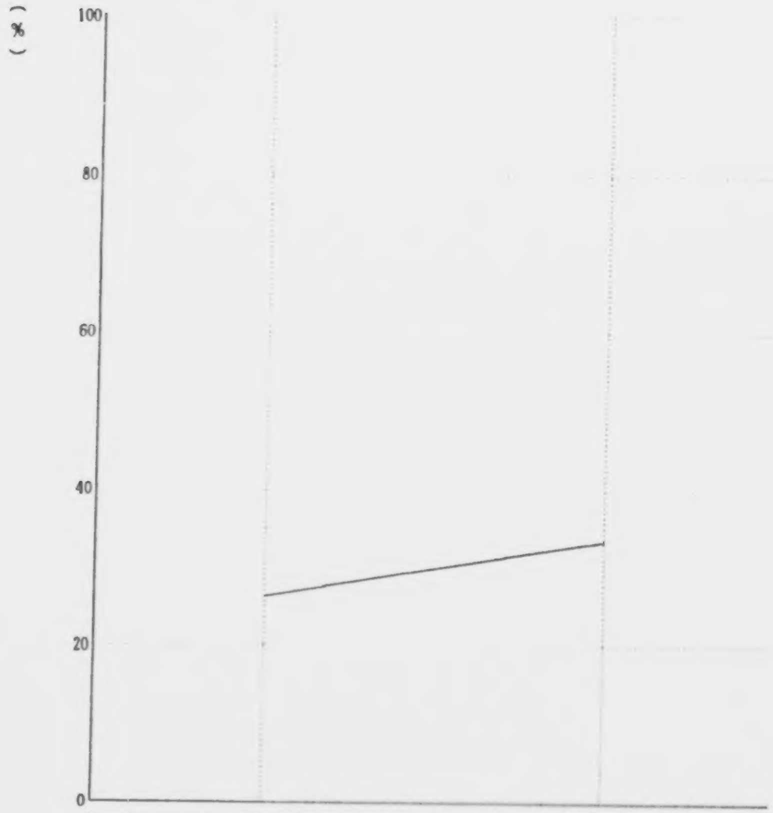


FIGURE 45

CORRECT RESPONSES IN ALL REVISED GALT SUBSCALES IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX male pupils who were able to answer correctly the reasoning skills problems were more than those of the females.

The performance of the elementary school pupils from Japan as affected by their grade levels was presented in Figure 46. The data presented that the percentage of Grade 6 pupils who were able to answer the problems was more than those of Grade 5 pupils. It can therefore be stated that the grade level of pupils have a direct effect on the performance of the pupils on the different subscales of the reasoning skills test.

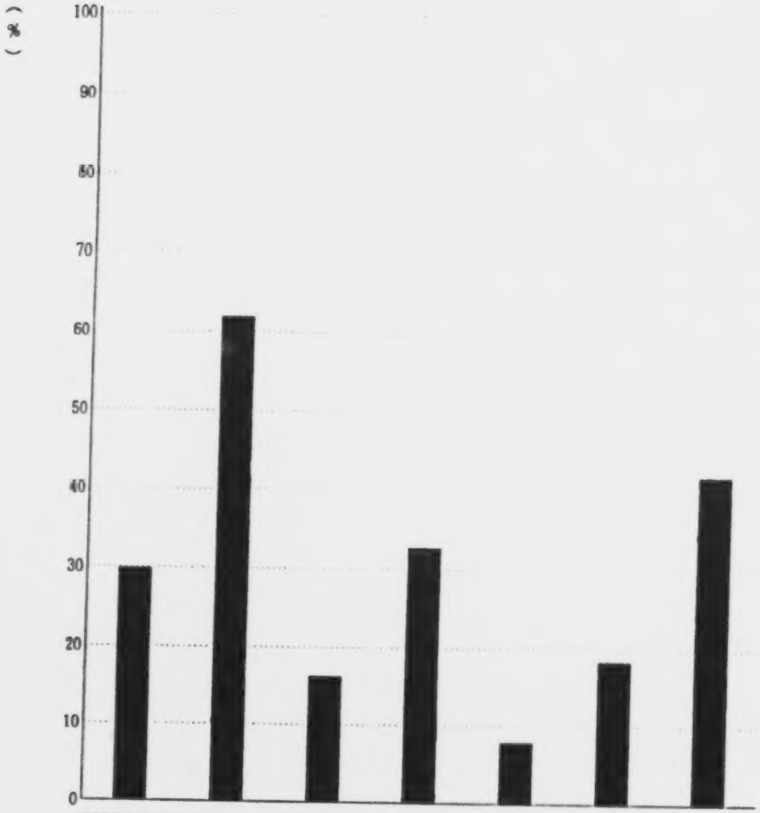
The performance result of the pupils on the different subscales of the revised reasoning skills test were presented in Figure 47. It could be noted from the data that the problem on Conservation (G1) were solved correctly by more pupils than those of the other skills. The skill that can be considered as the least correctly responded problem among the reasoning skills was on Probability (G4) since only 8.0% of the pupils were able to respond to the problem on it correctly. The problems that seemed to follow Conservation (G1) on their being easy to be answered by the pupils belong to Combination (G6) and Controlling Variable (G3) reasoning skills. The problem on Correlation (G5) and Proportion (G2) can also be considered as slightly easy ones for the pupils since both comes next to the most difficult problems in terms of the percentage who were able to answer them correctly. Comparing the results of the correlation (G5) taken from the elementary pupils and the secondary school students in Japan it could be noted that the number of elementary pupils who were able to get correctly the answer was more than those who



5th	6th
26.3	33.4

FIGURE 46

CORRECT RESPONSES IN ALL REVISED GALT SUBSCALES IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL

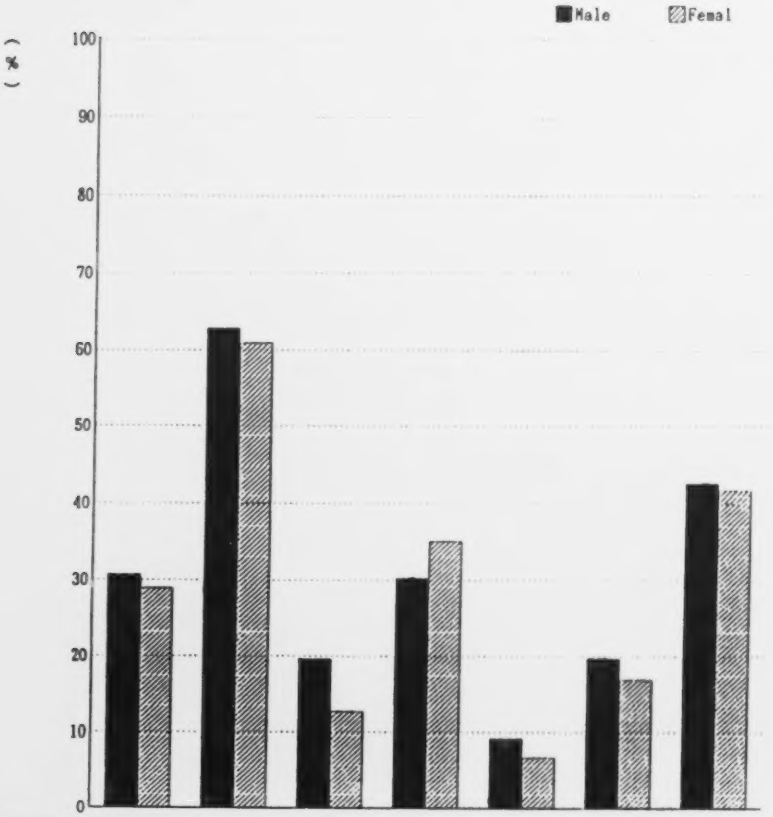


Total	G1	G2	G3	G4	G5	G6
29.9	61.9	16.2	32.7	8.0	18.4	42.2

FIGURE 47

CORRECT RESPONSES IN EACH REVISED GALT SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN were able to answer correctly this same skill for the secondary school students. The Correlation (G5) problem used in both levels were not the same and so the result comes out to be increasing the percentage of elementary school pupils getting the correct answers. So, the number of pupils who were able to get correct answers for the Correlation (G5) subscales were more than those who were able to answer correctly the same skills for the secondary school students. The Correlation (G5) problems used in both levels were not the same and so the result comes out to be increasing the percentage of elementary school pupils getting the correct answers. So, the number of pupils who were able to get correct answers for the correlation (G5) subscales were more than those who answered the Probability (G4) problems.

The percentage of pupils who were able to correctly answer the subscales of the revised reasoning skills test as affected by the sex difference were presented in Figure 48. It could be gleaned from the figure that the males acquired higher percentages than the females on the number of students who were able to answer correctly the problems related to Conservation (G1) and Combination (G6). However, no significant differences were found out between the result between the two sexes. This condition can be interpreted as the result of the developmental level, which can be classified as the concrete level, in which the pupils at Grade 5 and Grade 6 must have already reached. The pupils at this stage of education are known to have already reached the concrete level. Since the reasoning skills on Conservation (G1) and Combination (G6) are considered as concrete

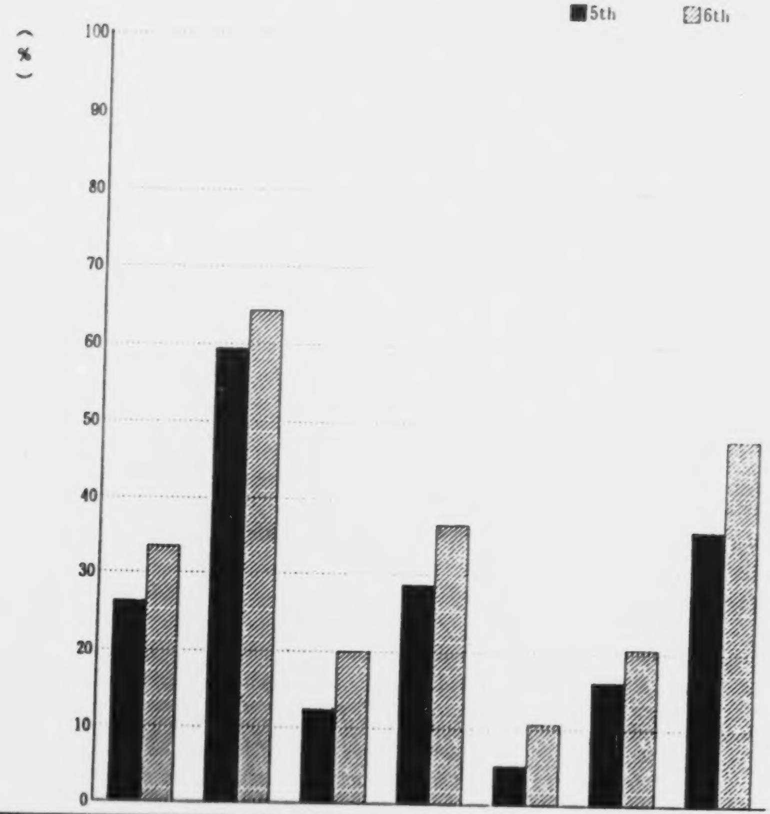


	Total	G1	G2	G3	G4	G5	G6
Male	30.7	62.9	19.6	30.3	9.3	19.7	42.6
Female	29.0	60.9	12.8	35.1	6.7	17.0	41.7

FIGURE 48

CORRECT RESPONSES IN EACH REVISED GALT SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX level tasks, then the male and female groups are expected to be able to solve these skills without significant difference. However, it could be gleaned from the data that the males acquired significantly higher percentage than the females, with regard to the number of those who were able to correctly answer the problem on the reasoning skills such as Proportion (G2), Probability (G4), and Correlation (G5). The females significantly acquired higher percentage than the males on the Controlling Variables (G3) reasoning skills. The remarkable differences on the percentage of students who were able to answer correctly the problem on Proportion (G2), Probability (G4), Correlation (G5), and Controlling Variables (G3) reasoning scales as a result of sex in which the students belong was on the fact that these skills are considered to be for the formal level thinkers.

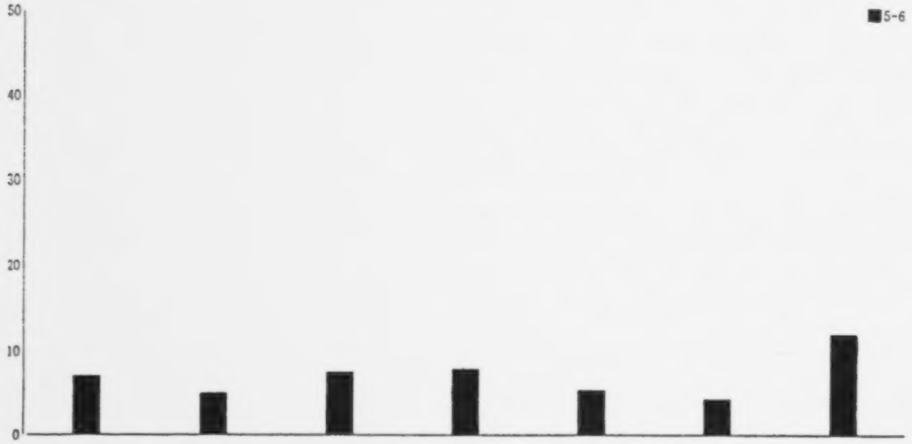
The percentage of pupils who were able to respond correctly to the problems on the reasoning skills subscales, as measured by Revised GALT, as affected by the school level in which they belong were presented in Figure 49. It could be observed from the data that the Grade 6 pupils have higher percentage than the Grade 5 pupils on the number of those who were able to answer correctly the problem in all the reasoning skills subscales. The effect of maturation as well as the advancement of knowledge and skills gained from exposure to education could probably explain this condition. The pupils in the higher grades acquired more experiences than the lower grade pupils. This difference could be due to the fact that most elementary schools emphasize the use of observation and experimentation in almost all



	Total	G1	G2	G3	G4	G5	G6
5th	26.3	59.4	12.4	28.7	5.3	16.2	36.1
6th	33.4	64.4	20.0	36.7	10.7	20.6	48.2

FIGURE 49

CORRECT RESPONSES IN EACH REVISED GALT SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL



	G.T.	G1	G2	G3	G4	G5	G6
5-6	7.1	5.0	7.6	8.0	5.4	4.4	12.1

FIGURE 50

REVISED GALT SUBSCALES GAIN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL activities in the science classes. Hence, pupils with more practical experiences have the decided advantage in solving problems that need their reasoning skills. The developmental levels of the pupils enrolled in the higher grades undoubtedly can be considered as more advanced than those who are still in the lower grades. Teachers should take advantage of the maturity and experience of the students in helping them acquire the proper skills that are related to reasoning.

The subscales of reasoning skills gain demonstrated by the elementary school pupils in Japan by grade level is shown in Figure 50. There appears to be an almost constant gain by the Grade 5 and Grade 6 pupils on five of the six reasoning subscales. These subscales dealt on Conservation (G1), Porportion (G2), Controlling Variables (G3), Probability (G4), and Probability (G5). Only on Combinatorial Reasoning (G6) did the pupils gained more.

The percentage of pupils who provided correct responses to the each of the revised GALT subscale in Japan by grade and sex level are presented in Table 32. Based on the total group result the subscale on Conservation appeared to be the easiest while the subscale on Probabilistic Reasoning appeared to be the most difficult where only 8.0% of the students were able to get it correctly. The same trend was observed when the data was analyzed by sex and by grade level. The subscale on Conservation was the easiest for both the males and the females as well as for Grade 5 and Grade 6 students. By sex, the responses of the female students were slightly better than those of the male students

TABLE 32

CORRECT RESPONSES IN EACH REVISED GALT SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE LEVEL

	Total Group	by Sex		by Grade	
		MALE	FEMALE	5TH	6TH
GALT Total	29.9	30.7	29.0	26.3	33.4
G1 Conservation	61.9	62.9	60.9	59.4	64.4
G2 Proportional Reasoning	16.2	19.6	12.8	12.4	20.0
G3 Controlling Variables	32.7	30.3	35.1	28.7	36.7
G4 Probabilistic Reasonig	8.0	9.3	6.7	5.3	10.7
G5 Correlational Reasoning	18.4	19.7	17.0	16.2	20.6
G6 Combinatorial Reasoning	42.2	42.6	41.7	36.1	48.2

TABLE 33

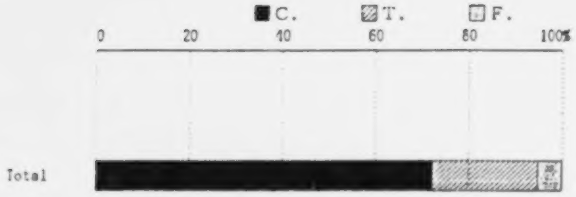
ANALYSIS OF VARIANCE MATRIX IN EACH REVISED GALT SUBSCALE OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE

	Sex Differences (df=1)	Grade Difference (df=1)
GALT Total	4.98•	85.46••
G1: Conservation	2.19NS	13.58••
G2: Proportional Reasoning	31.59••	39.19••
G3: Controlling Variables	8.84••	25.83••
G4: Probabilistic Reasoning	6.36•	28.39••
G5: Correlational Reasoning	4.11•	10.51••
G6: Combinatorial Reasoning	0.45NS	65.53••

on the subscale on controlling variables. But, by and large, the the male students generally responded better than the female students in the subscales. By grade level, it is not surprising to note that the responses of the Grade 6 pupils were far better than those of the Grade 5 pupils. This is to be expected as pupils in a higher grade level must be more mature and experienced than those in the lower grade levels. The analysis of variance in each of the GALT subscale , shown in Table 33, further supports this claim. Take note that sex difference has a significant effect on the ability of the pupils to solve problems requiring their reasoning skills. The performance of the pupils in two subscales, Conservation (G1) and Combinatorial Reasoning (G6), however, were not in any way affected by sex difference. On the other hand, grade difference was significantly related to the performance of the pupils in all the subscales. Hence, having a level of cognitive maturity as well as an increase in educational experience is very helpful in performing well in problems requiring the reasoning skills.

Another factor which was thought to be necessary to understand better the learning capabilities of Japanese pupils was to determine their developmental levels. The distribution of their developmental levels are shown in Figure 51. The developmental levels were determined according to three categories, namely, by`their total scores, their sex and their grade level. As in the previous study the developmental level was classified into three types: Concrete (C), Transitional (T), and Formal (F). It appears that based on the total scores of the

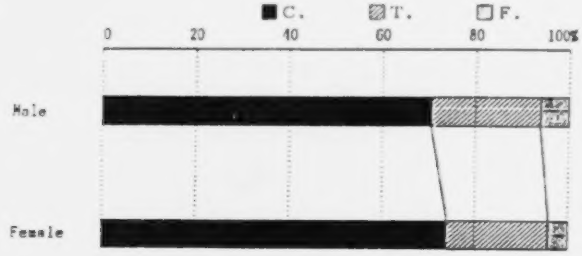
Total Group



	Total
C.	72.1
T.	22.6
F.	5.3

(%)

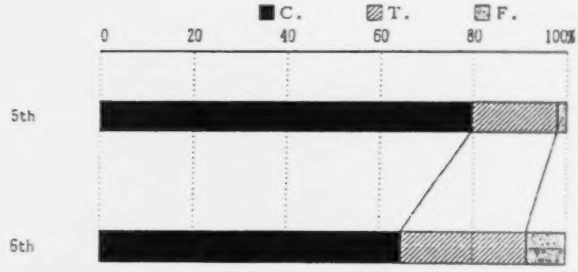
by Sex



	Male	Female
C.	70.4	73.8
T.	23.3	21.8
F.	6.2	4.4

(%)

by Grade



	5th	6th
C.	79.6	64.6
T.	18.4	26.8
F.	2.1	8.6

(%)

FIGURE 51

DEVELOPMENTAL LEVEL DISTRIBUTION
OF ELEMENTARY SCHOOL PUPILS IN JAPAN

pupils. About three-fourths or 72% of the sample pupils used are still in the concrete level while only about 5% are already in the formal level.

With regards to sex as the variable factor, there seems to be just a slight difference in the number of males and females that are in each of the developmental stages. There are slightly more females than males who are still concrete level thinkers. On the other hand, there are slightly more males than females who are already transtional and formal level thinkers.

With grade level as the determining factor, there are more concrete level thinkers in Grade 5 while there are more transitional and formal thinkers in Grade 6. However, on the whole, there is still a large percentage of concrete level thinkers in both Grades 5 and 6 while only a small percentage, less than 10%, are formal level thinkers. It might be worthwhile for educators to consider this difference if an improvement of the developmental levels of pupils is so desired.

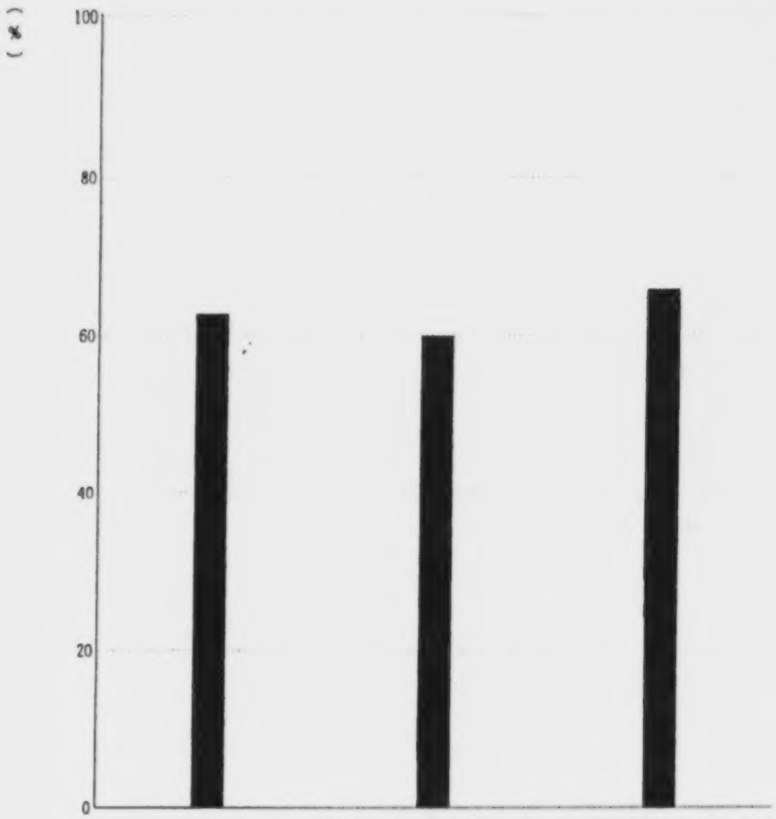
2. Science Process Skills of Pupils in Japan and the United States

The performance of the pupils on the different process skills had been measured by the instrument called "Performance of Process Skills (POPS) test. The POPS test was composed six subscales, namely: Identifying Experimental Questions (P1), Identifying Variables (P2), Formulating Hypotheses (P3), Designing Investigations (P4), Graphing Data (P5), and Interpreting Data (P6). These subscales were used to determine if differences in sex and grade level could result in differing performance of pupils using some previously selected process skills. The samples used were pupils enrolled in the elementary and middle grade school in some parts of Japan and the United States.

The graph in Figure 52 shows the percentage of pupils from Japan who correctly answered the items in the POPS test. More than 60% of the total samples were able to answer the items correctly. When the pupils were separated by sex, it was found out that more females than males were able to answer the items correctly. This finding seems to indicate that when it comes to process skills, females are able to perform better.

As expected, when the test was also administered to pupils of two grade levels, Grade 5 and Grade 6, the Grade 6 pupils performed better as shwon in Figure 53. This indicates that there is a significant improvement in the process skills of pupils as they move from a lower to a higher grade level, which could most probably be due to their increase exposure and experience, not only in the classroom but also in their environment. At the same time, a one year increase in chronological age could help increase the pupils' maturity, and thus enable them to improve their process skills.

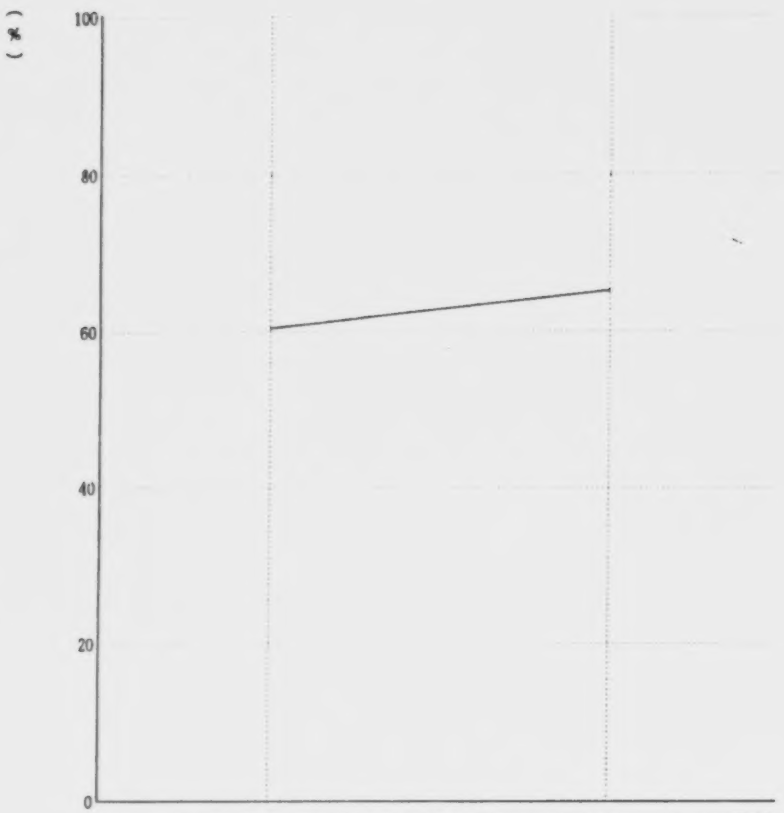
To support further the findings mentioned above, the responses of the pupils in each of the subscales was determined and the data shown in Figure 54 and Table 34. The pupils apparently performed best on the subscale on Identifying Variables (P2). A little less than three-fourths of the total



Total	Male	Female
62.8	59.9	65.8

FIGURE 52

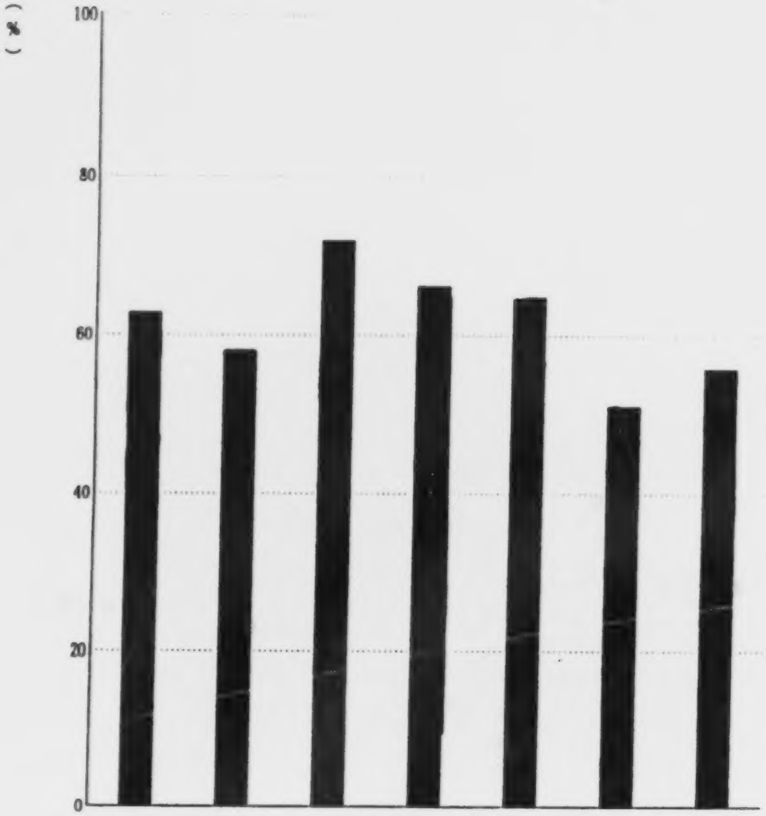
CORRECT RESPONSES IN ALL POPS SUBSCALES IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX



5th	6th
60.5	65.2

FIGURE 53

CORRECT RESPONSES IN ALL POPS SUBSCALES IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL



P.T.	P1	P2	P3	P4	P5	P6
62.8	58.0	71.9	66.1	64.8	51.3	56.0

FIGURE 54

CORRECT RESPONSES IN EACH POPS SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN sample answered the qustions on this subscale correctly. The pupils also found that formulating hypotheses (P3) and designing investigations (P4) rather easy as can be seen from the percentage of responses on these subscales. The subscale that was found to be the most difficult was on graphing data (P5) where slightly more than half of the pupils answered it correctly. All in all, however, the test did not seem to be difficult as more than half of the pupils answered all the items correctly.

The same trend was observed when the responses of the pupils to each of the subscales were analyzed according to their sex as shown in Figure 55 and Table 34. Both males and females found the subscale on identifying variables (P2) the most easy while the subscale on graphing data (P5) the most difficult. The females performed better than the males in all the subscales. However, except the subscale on graphing data (P5), the performance of the males and the females in all the subscales were found to be significantly different based on the analysis of variance in each subscale as shown in Table 35.

Again as expected, the Grade 6 pupils performed better than the Grade 5 pupils in all the subscales as shown in Figure 56 and Table 34. The subscale on identifying variables (P2) was also found to be the most easy by both Grade 5 and Grade 6 pupils while the subscale on graphing data (P5) was found to be the most difficult. Although the subscale on identifying experimental questions (P1) was not found to be either the most easy or most difficult, surprisingly, the difference in performance of Grade 5 and Grade 6 pupils on it had been found to be insignificant. All

TABLE 34

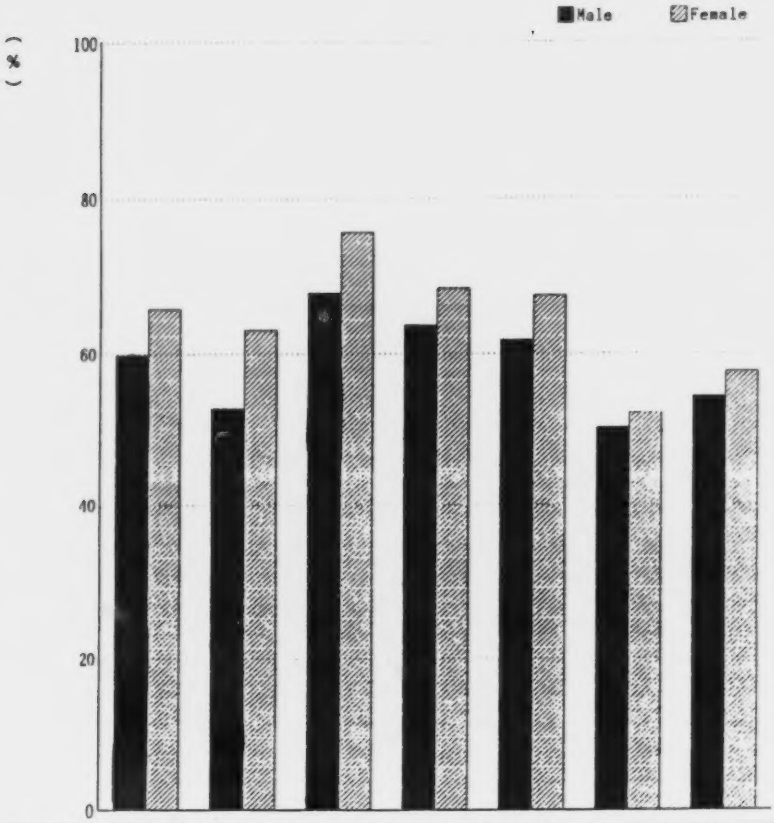
CORRECT RESPONSES IN EACH POPS SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE LEVEL

	Total Group	by Sex		by Grade	
		MALE	FEMALE	5TH	6TH
POPS Total	62.8	59.9	65.8	60.5	65.2
P1 Identifying Experimental Questions	58.0	52.8	63.1	57.5	58.5
P2 Identifying Variables	71.9	67.9	75.8	69.2	74.6
P3 Formulating Hypothesis	66.1	63.7	68.4	63.9	68.3
P4 Designing Investigation	64.8	61.9	67.5	61.5	68.0
P5 Graphing Data	51.3	50.3	52.2	48.1	54.4
P6 Interpreting Data	56.0	54.4	57.6	53.8	58.3

TABLE 35

ANALYSIS OF VARIANCE MATRIX IN EACH POPS SUBSCALE OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE

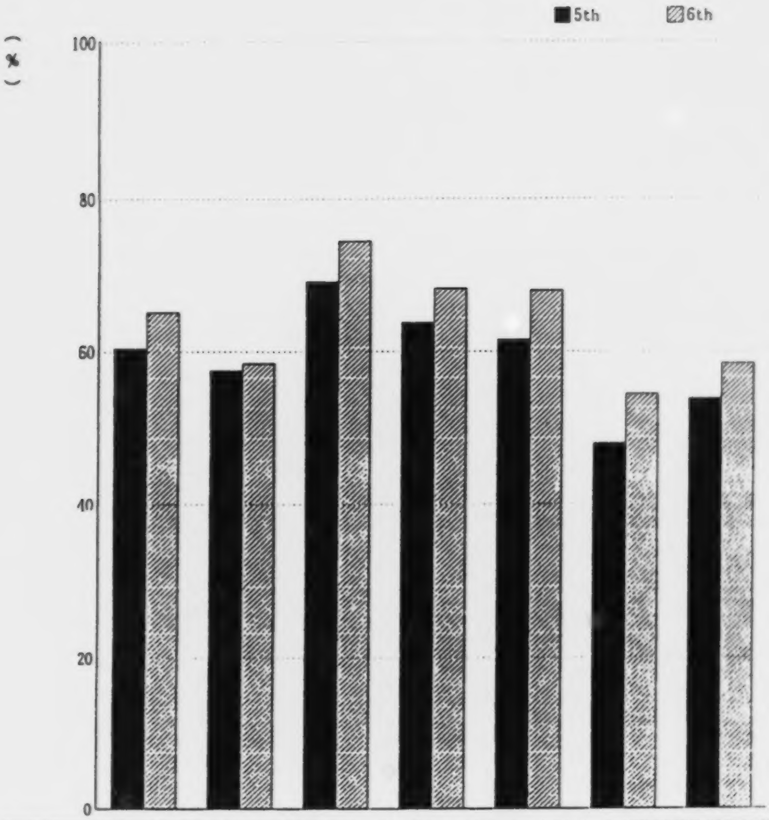
	Sex Differences (df=1)	Grade Differences (df=1)
POPS Total	40.42••	27.66••
P1: Identifying Expreimental Questions	60.54••	0.82NS
P2: Identifying Variables	41.26••	20.40••
P3: Formulating Hypothesis	14.85••	13.75••
P4: Designing Investigations	15.08••	20.87••
P5: Graphing Data	1.66NS	18.66••
P6: Interpreting Data	4.42•	9.07••



	P.T.	P1	P2	P3	P4	P5	P6
Male	59.9	52.8	67.9	63.7	61.9	50.3	54.4
Female	65.8	63.1	75.8	68.4	67.5	52.2	57.6

FIGURE 55

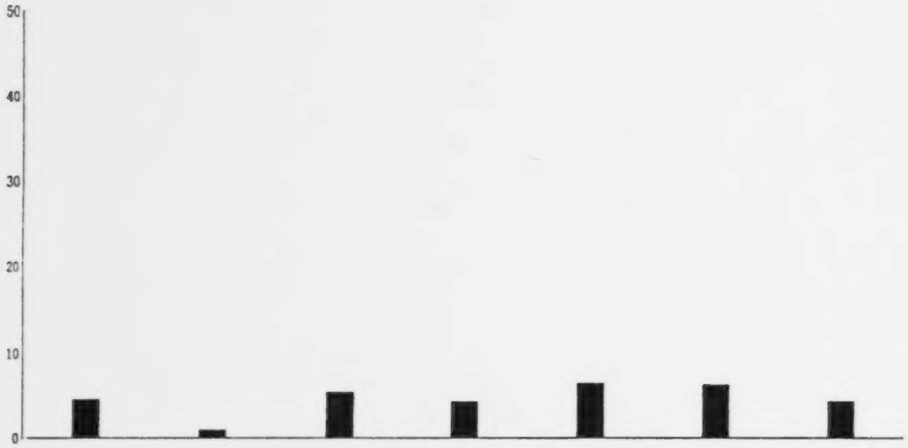
CORRECT RESPONSES IN EACH POPS SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX



	P.T.	P1	P2	P3	P4	P5	P6
5th	60.5	57.5	69.2	63.9	61.5	48.1	53.8
6th	65.2	58.5	74.6	68.3	68.0	54.4	58.3

FIGURE 56

CORRECT RESPONSES IN EACH POPS SUBSCALE IN PERCENT OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL



	P.T.	P1	P2	P3	P4	P5	P6
5-6	4.7	1.0	5.4	4.4	6.5	6.3	4.5

FIGURE 57

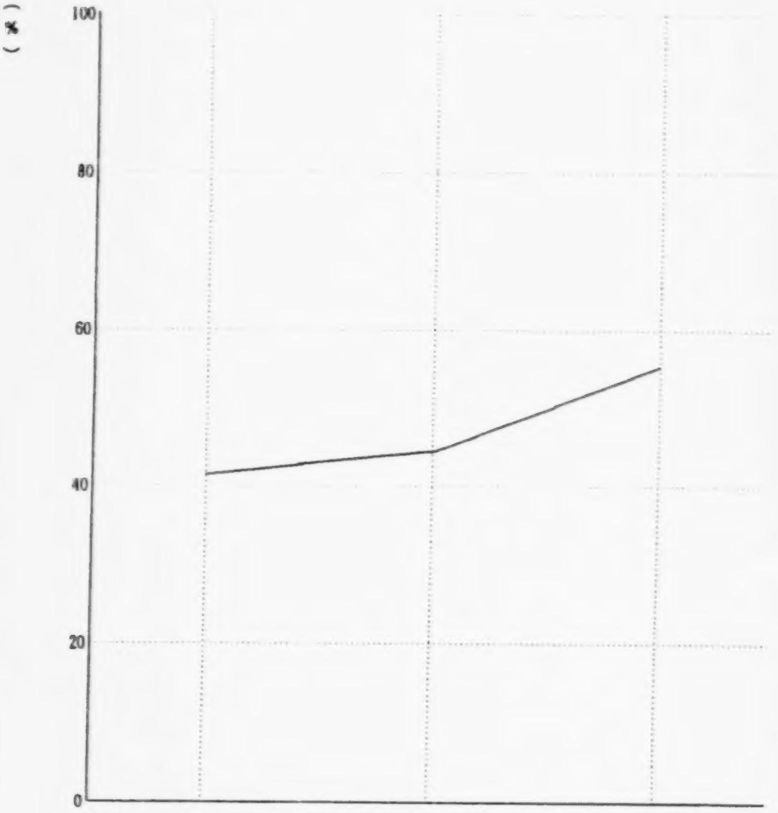
POPS SUBSCALES GAIN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL the other five subscales showed significant differences on the performance of both Grades 5 and 6 pupils based on the analysis of variance on each of the subscales shown in Table 35.

Knowing the significant differences in the performance of the pupils, it was deemed necessary to determine too the gain of the pupils in each of the subscales as they progressed from one grade level to another. It is apparent from the graph, shown in Figure 57, that the pupils did not demonstrate any considerable gain on the subscale on identifying experimental questions (P1). One reason could probably be due to lack of opportunity to find solution to problems by themselves. Their learning experience then became limited that they did not have the chance to develop this skill fully. On the other hand, the pupils demonstrated an almost constant gain, although seemingly not sizeable, in the other six subscales. It can therefore be suggested that the teachers should do provide the pupils the proper experience suitable for each grade level so the pupils can improve more on their process skills. One way is to provide the pupils with more hands-on activities, especially those that require identifying experimental questions, and graphing data.

The researchers have decided to administer the same POPS test to some middle school pupils in the United States, not to compare their performances with those of Japanese pupils but simply to assess how well they perform on the test. Comparisons can be quite difficult to do at this stage since the grade levels are not exactly the same.

The percentage of pupils from the United States that correctly responded to all the POPS subscales by grade level was first determined. From the data gathered, which is shown in Figure 58, it appeared that Grade 8 pupils performed better than the Grade 6 and Grade 7 pupils. More than 50% of the pupils in Grade 8 responded correctly to all the POPS subscales compared to only a little over 40% of the pupils in either Grade 6 or Grade 7. A trend is very evident in the figure. The inclination of the slope to the right indicates that there is a general improvement in the process skills of the pupils as they progress from Grades 6 to 7 and to Grade 8. However, the slight inclination of the slope representing Grades 6 to 7 does indicate that the improvement was slight and so is considered not significant. On the other hand, the steep slope representing Grades 7 to 8 indicates a relatively large improvement and hence is considered as significant. This significant improvement may be due partly to the proper development of the pupils' process skills while they were in their lower grade levels. Another part could be due to the increase in their experiences as they become more aware of their surroundings. Still another part of the reason could be that as their chronological age increases, their maturity level increases and so are able to understand more the varied tasks that they are made to perform.

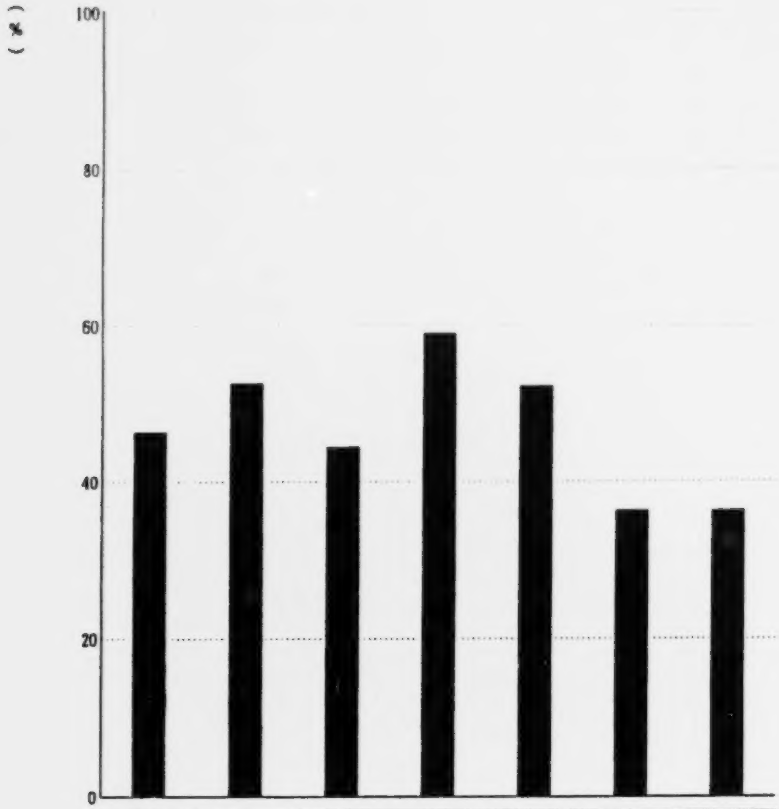
To shed more light to the preceeding findings, the responses of the pupils were further analyzed according to how they responded to each of the subscales, in total and by grade level. It appeared that less than half of the total number of pupils who took the test were able to answer the items in all the subscales



6th	7th	8th
41.5	44.4	55.4

FIGURE 58

CORRECT RESPONSES IN ALL POPS SUBSCALES IN PERCENT OF MIDDLE SCHOOL PUPILS IN THE UNITED STATES BY GRADE LEVEL



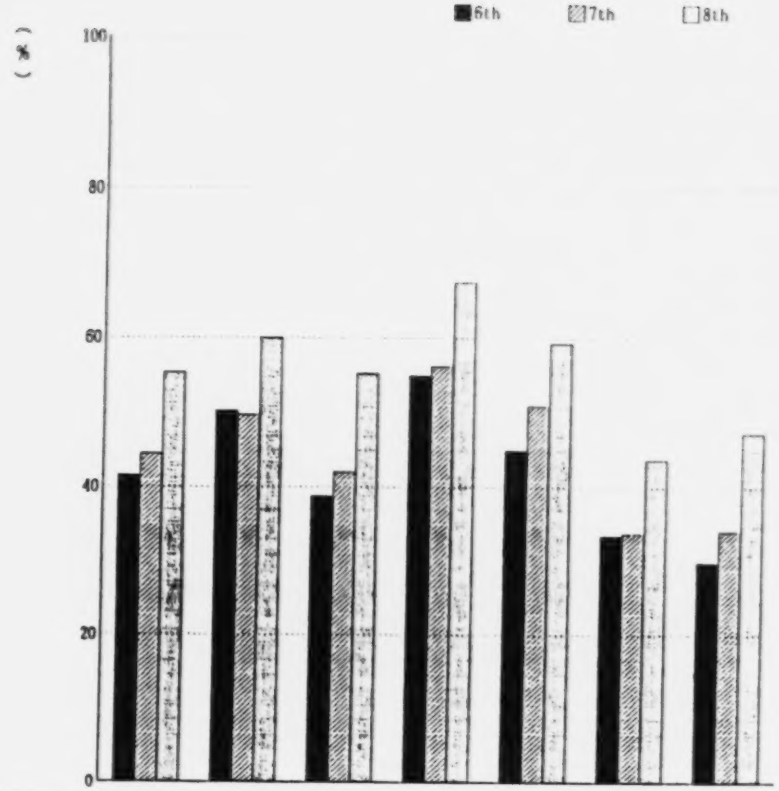
Total	P1	P2	P3	P4	P5	P6
46.5	52.7	44.5	59.0	52.3	36.3	36.3

FIGURE 59

CORRECT RESPONSES IN EACH POPS SUBSCALE IN PERCENT OF MIDDLE SCHOOL PUPILS IN THE UNITED STATES correctly, as shown in Figure 59. The subscale which was answered correctly by the greatest number of pupils was that on formulating hypothesis (P3), followed by two subscales, those on identifying experimental questions (P1) and designing variables (P4). Apparently these subscales have almost the same difficulty level as they garnered almost the same number of correct pupils' responses. Two subscales were found to be the most difficult, those on graphing data (P5) and interpreting data (P6) since less than 40% of the pupils were able to answer these sunscales correctly.

It is worthwhile to consider at this point that the pupils from Japan and the United States found the same subscales, those on graphing data (P5) and interpreting data (P6), as the most difficult ones. Graphing and interpreting data are actually considered difficult tasks because both require the ability of the pupils to describe relationships between variables. In science, these are often required during and after performing an experiment. It is therefore fitting and proper that teachers should give more emphasis on the development of these skills in their lessons, and start at the lower grade levels, if possible.

The pupils responses on each of the subscales according to their grade level is shown in Figure 60. Just as the pupils in Japan improved their process skills as they moved up the educational ladder, the same trend was observed on the performance on each of the subscales of the pupils from the United States. It is very much evident in Figure 60 that Grade 8 pupils performed far better than either Grade 6 or Grade 7



	P.T.	P1	P2	P3	P4	P5	P6
6th	41.5	50.3	38.8	55.0	45.0	33.3	29.7
7th	44.4	49.7	42.0	56.3	51.0	33.7	34.0
8th	55.4	60.0	55.3	67.3	59.3	43.7	47.3

FIGURE 60

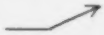
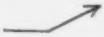
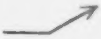
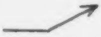
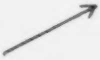
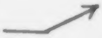
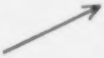
CORRECT RESPONSES IN EACH POPS SUBSCALE IN PERCENT OF MIDDLE SCHOOL PUPILS IN THE UNITED STATES BY GRADE LEVEL pupils. The data further supports the observation made on Figure 58, that generally there is an improvement on the process skills of the pupils as they progress from the lower to the higher grade level and the improvement is greater among Grade 8 pupils.

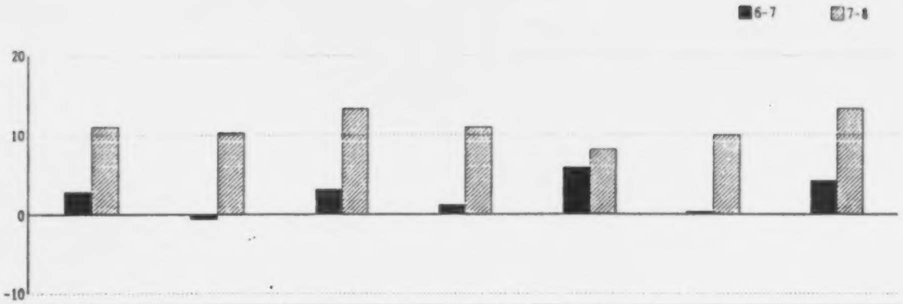
In some of the subscales, however, such as identifying experimental questions (P1) and graphing data (P5), the performance of the pupils was almost the same. But again, a similar trend can be observed with regards to the difficulty of the subscales. The subscale on formulating hypothesis was again found to be the most easy by Grades 6, 7, and 8 pupils. Grade 6 pupils found the subscale on interpreting data (P6) as the most difficult. On the other hand, Grade 7 and Grade 8 pupils found the subscale on graphing data as (P5) as the most difficult.

While Grade 8 pupils performed best in all the POPS subscales, it can be implied that they must have had the greatest gain among all the samples. And true enough, Table 36 and Figure 61 support this implication. The Grade 8 pupils posted the greatest gain in all the subscales particularly identifying variables and interpreting data. It may be recalled in the preceeding findings, that Grade 6 pupils found this subscale the most difficult. Pupils must have received much exposure and training on these skills while in Grades 6 and 7 that by the time they reached Grade 8 they must have improved on this skill considerably, hence they found the subscale the most easy. The least gain they had was on designing investigations (P4). In the case of of Grade 6 and Grade 7 pupils, there appeared some kind

TABLE 36

POPS SUBSCALES GAIN OF MIDDLE SCHOOL PUPILS IN THE UNITED STATES BY GRADE LEVEL

	by Grade		
	Score Gain (6-7,7-8)		Pattern 6 7 8
POPS Total	6-7	NS + 2.9	
	7-8	• +11.0	
P1 Identifying Experimental Questions	6-7	NS - 0.6	
	7-8	• +10.3	
P2 Identifying Variables	6-7	NS + 3.2	
	7-8	• +13.3	
P3 Formulating Hypothesis	6-7	NS + 1.3	
	7-8	• +11.0	
P4 Designing Investigations	6-7	• + 6.0	
	7-8	• + 8.3	
P5 Graphing Data	6-7	NS + 0.4	
	7-8	• +10.0	
P6 Interpreting Data	6-7	• + 4.3	
	7-8	• +13.3	



	P.T.	P1	P2	P3	P4	P5	P6
6-7	2.9	-0.6	3.2	1.3	6.0	0.4	4.3
7-8	11.0	10.3	13.3	11.0	8.3	10.0	13.3

FIGURE 61

POPS SUBSCALES GAIN OF MIDDLE SCHOOL PUPILS IN THE UNITED STATES BY GRADE LEVEL of a pattern in four of the subscales. The Grade 6 and Grade 7 pupils had almost constant gains on identifying experimental questions, identifying variables, formulating hypotheses, and graphing data.

3. Intercorrelation Between Reasoning Skills and Science Process Skills

The reasoning skills and science process skills possessed by the elementary school pupils in Japan were measured with two different instruments. One instrument is called the Revised Group Assessment of Logical Thinking (Revised GALT) and the other is the Performance of Process Skills (POPS) Test. After administering the two instruments, the results were statistically correlated and now are presented in Table 37. Based on Pearsons Product Correlation Moment, the Revised Galt total and POPS total were found to be significantly correlated. The same has been found true to all Galt subscales and POPS subscales.

It is apparent on the data that the total reasoning skills has been correlated to all the subscales of the test of science process subscales. The skills that correlated highly to the reasoning skills total included all the 6 process skills. In like manner, the process skills total also acquired a considerably high correlation to all the 6 subscales of the revised GALT.

The Combination (G6) subscale of the revised group assessment of reasoning skills has been observed to possess a high significant correlation to all the 6 process skills

TABLE 37

CORRELATION COEFFICIENT MATRIX BETWEEN REVISED GALT AND POPS SUBSCALES

	GALT Total	G1	G2	G3	G4	G5	G6
POPS Total	.54••	.26••	.29••	.42••	.24••	.28••	.36••
P1	.30••	.12••	.14••	.26••	.13••	.16••	.20••
P2	.43••	.24••	.22••	.35••	.16••	.22••	.28••
P3	.35••	.19••	.18••	.26••	.16••	.19••	.21••
P4	.40••	.18••	.23••	.31••	.19••	.19••	.25••
P5	.32••	.12••	.17••	.25••	.17••	.17••	.23••
P6	.42••	.17••	.22••	.31••	.20••	.23••	.28••

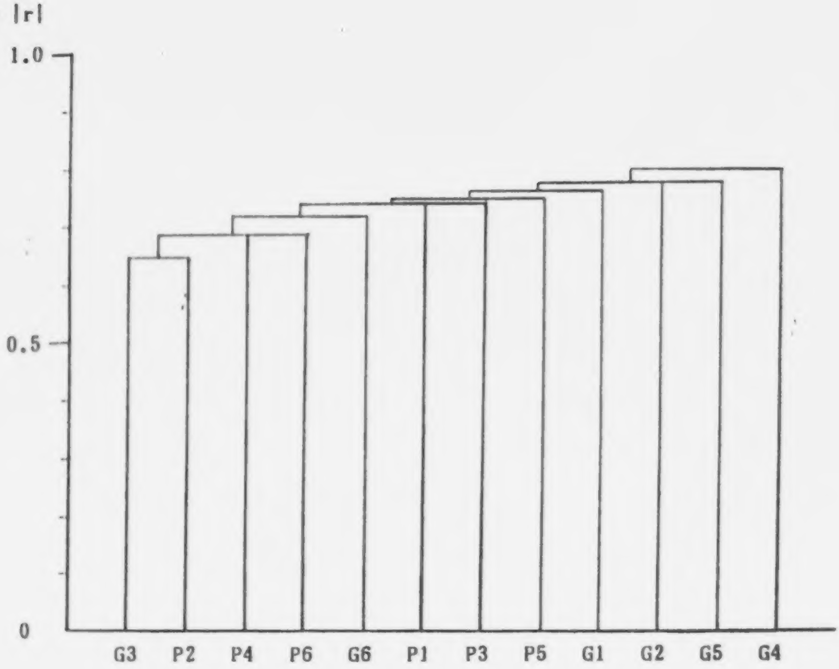


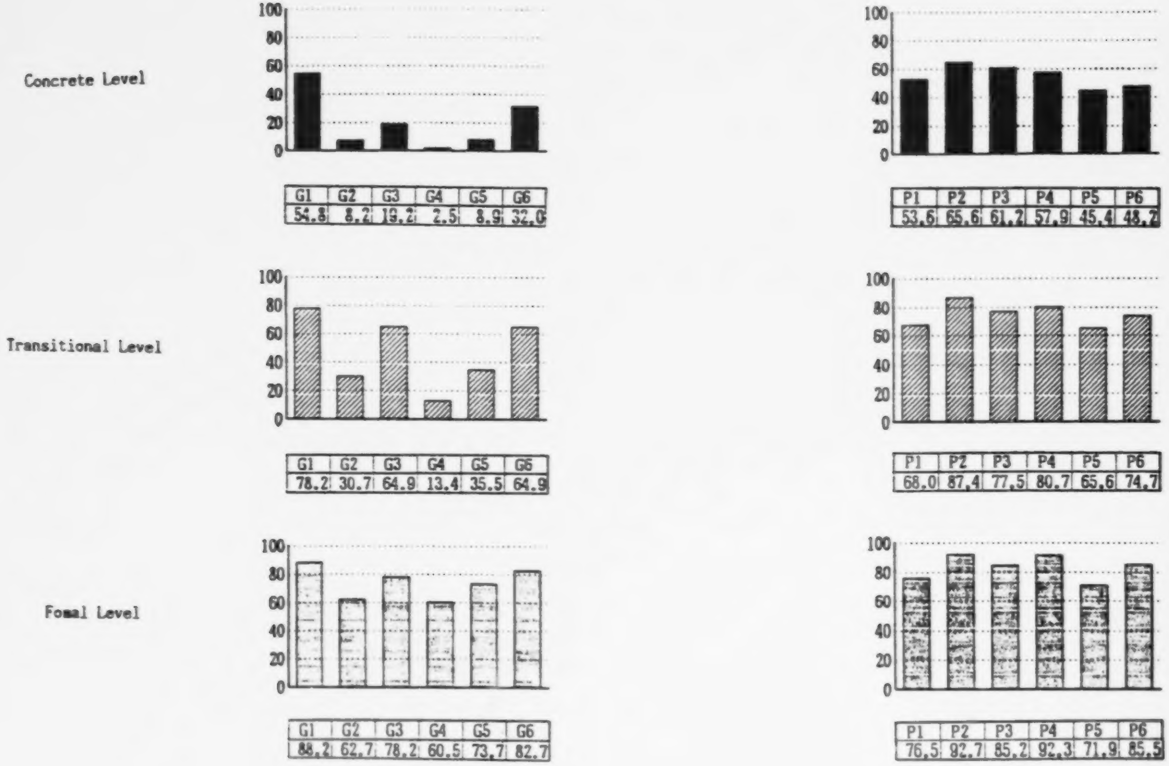
FIGURE 62

REVISED GALT AND POPS SUBSCALES DENDOGRAM subscales. The same condition also exist between the Controlling Variables (G3) subscale of the reasoning skills to the 6 process skills subscales mentioned above.

It can also be observed that a high positive correlation also exist between the subscale Interpreting Data (P6) and five of the reasoning skills (G2 to G6). Although the correlation between the subscales Interpreting Data (P6) and Conservation (G1) has been significant, the correlation coefficient cannot be considered as high as the rest of the other correlations.

In order to understand fully the significant intercorrelations that existed among the reasoning and science process skills subscales, the data in Figure 62 is worthwhile analyzing because of the representations of all the subscales based on the correlation coefficient values. The dendogram suggests that all the reasoning and process skills belong to a common group of pupils. Also it shows that the reasoning subscales, designed to measure the reasoning skills, are in fact reasoning such skills.

After the analysis on the intercorrelation between the two skills, the performance of the students by developmental levels on these skills was also analyzed. The percentage of pupils who were able to answer the items on scientific thinking skills is shown in Figure 63. It could be noted from the data that majority of the pupils, whatever developmental level they belonged to, were able to answer the subscale on Conservation (G1). The same observation could be made on Combination (G6) subscale. The other four subscales were also found out to show progress along with



Concrete Level

G1	G2	G3	G4	G5	G6
54.8	8.2	19.2	2.5	8.9	32.0

P1	P2	P3	P4	P5	P6
53.6	65.6	61.2	57.9	45.4	48.2

Transitional Level

G1	G2	G3	G4	G5	G6
78.2	30.7	64.9	13.4	35.5	64.9

P1	P2	P3	P4	P5	P6
68.0	87.4	77.5	80.7	65.6	74.7

Fomal Level

G1	G2	G3	G4	G5	G6
88.2	62.7	78.2	60.5	73.7	82.7

P1	P2	P3	P4	P5	P6
76.5	92.7	85.2	92.3	71.9	85.5

FIGURE 63

CORRECT RESPONSES IN EACH REVISED GALT AND POPS SUBSCALES OF OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY DEVELOPMENTAL LEVELS the developmental levels of the pupils. A sequential growth, as depicted by the variation in the percentage of pupils, can b eobservable among the progress made on the different subscales as affected by the developmental levels of the pupils. The Conservation (G1) and Combination (G6), which were considered as tasks for concrete level thinkers, has also been observed to have shown progress along with the developmental level growth from concrete to formal. It could also be noted that the pupils who were categorized as having reached the formal level showed a performance wherein all subscales of the reasoning skills were adequately responded to by them. The variation of the percentages among the subscales has therefore decreased sharply. This must be the situation because the pupils have already reached the formal level of reasoning and so they are expected to be able to answer problems at the formal level with ease.

The data related to the science process skills as shown in Figure 63 suggest that total developmetn of all the skills can be observable because the percentage of pupils in each of the subscales seem to be having just a slight variation in any of the developmental levels. At the concrete level, for example, the existence of lesser variation of the percentage of pupils who were able to correctly answer the problem related to each subscale can be found. This condition was also depicted on the performance of the transitional and formal group members. However, the performance in the different subscales of the process skills of the pupils is directly related to the developmental levels in which they belong.

The difficulty index of each of the reasoning skills is shown in Figure 64. It would be noted from the data that the pupils seemingly experienced difficulty in solving problems related to Probability (G4) if the total group were to be considered. This is also true whether the classification would be by grade or developmental level of the pupils. The easiest problem in all the classifications were that of Conservation (GI) as depicted on the data.

The data on the difficulty index presented in Figure 64 also depicted the fact that the different reasoning skills seemed to consolidate into unified level of difficulty as the pupils move towards the formal developmental levels. This would mean an increase on the capability of the pupils to deal with all the reasoning skills subscales as a result of their having reached the formal developmental level. Wider desparsity of the difficulty index can be observed among the pupils classified to be at the transitional and concrete developmental levels.

The data on the difficulty index as exemplified by the performance of the pupils in each of the process skills in science by grade and developmental levels has been presented in Figure 65. It could be noted from the data that the pupils in Japan seemingly have encountered most difficulty in the process skills problems related to Graphing Data (P5). The easiest problems were of the Identifying Variables (P2). These conditions were true to all classifications, i.e. total group, grade, and developmental level. It could be observable from the data related to grade, however, that the Grade 5 pupils were able

FIGURE 64

DIFFICULTY INDEX AMONG REVISED GALT SUBSCALES IN JAPAN BY GRADE AND DEVELOPMENTAL LEVELS

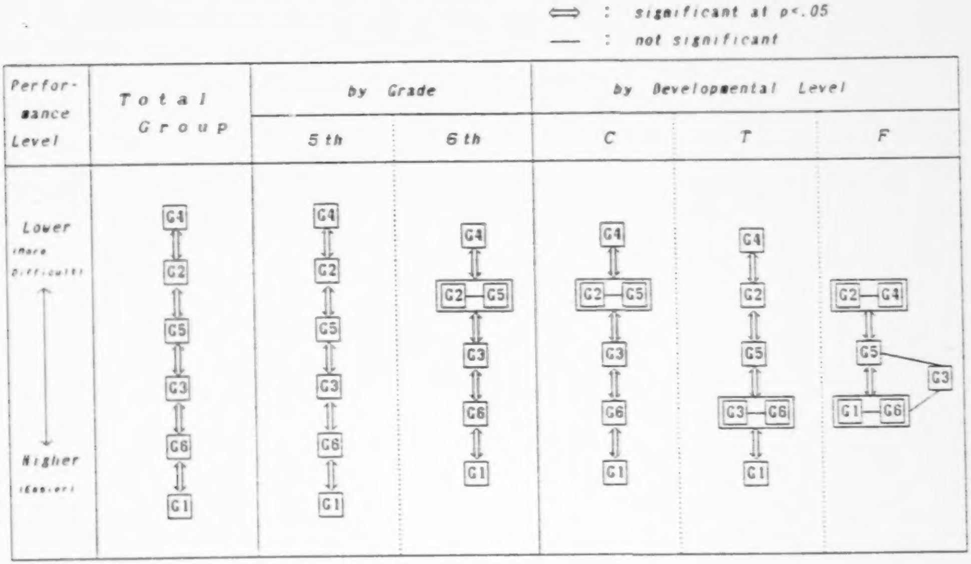
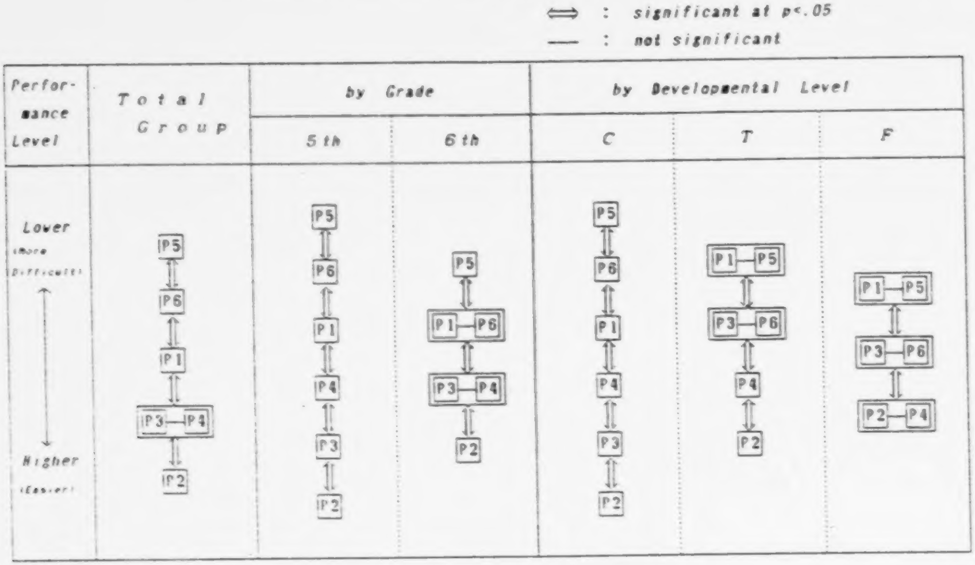

⟺ : significant at p<.05
— : not significant
Perfor-mance Level
Total Group
by Grade
5th
6th
by Developmental Level
C
T
F
Lower (more Difficult)
Higher (Easier)
G4
G2
G5
G3
G6
G1

FIGURE 65

DIFFICULTY INDEX AMONG POPS SUBSCALES IN JAPAN BY GRADE AND DEVELOPMENTAL LEVELS

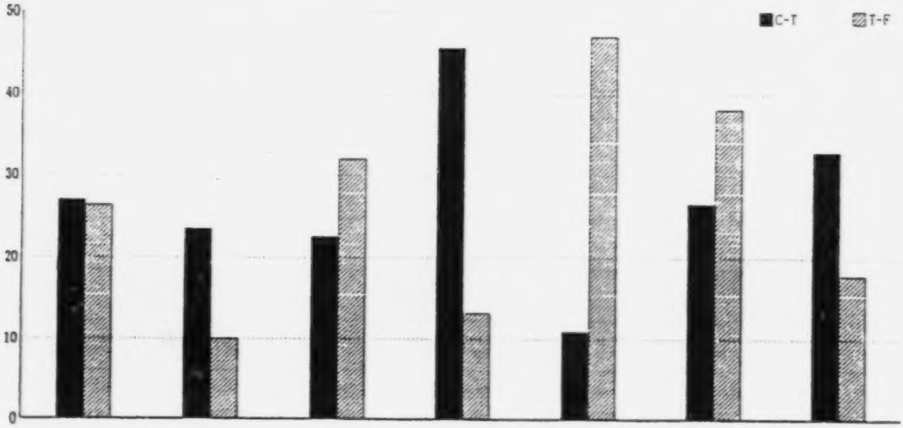

⟺ : significant at p<.05
—— : not significant
Performance Level
Total Group
by Grade
5th
6th
by Developmental Level
C
T
F
Lower (More Difficult)
Higher (Easier)
P5
P6
P1
P3
P4
P2
P1 — P6
P3 — P4
P1 — P5
P3 — P6
P2 — P4

to experience difficulty in each of the subscales proceed from the easiest to the most difficult. The Grade 6 pupils seemed to have exemplified subscales that acquired similar levels of difficulty such as for Identifying Experimental Questions (P1) and Interpreting Data (P6), and also for Formulating Hypothesis (P3) and Designing Investigations (P4). The difficulty level of the pupils therefore can be characterized to decrease as they move upward to the higher grade levels.

With regards to the developmental levels, as shown in Figure 65, it was found out that the formal level pupils seemingly have encountered comparable levels of difficulty in most of the process skilla since the levels can only be grouped into 3. The transitional level group members depicted the conditions wherein 4 levels can be observable. The 6 process skills subscales possessed varied levels of difficulties if the basis wer that of the concrete level thinkers. The process skills subscales therefore can be dealt with at a common difficulty index as the pupils move towards the formal developmental levels in cognition.

The data presented in Figure 66 depicted the gain acquired by the elementary pupils in Japan in each of the reasoning subscales by developmental levels. It could be noted from the data that the pupils at the concrete-transitional group were able to acquire more gain in Conservation (G1), Controlling Variables (G3), and Combination (G6). The remarkable gain of the pupils at the transitional-formal group has been found out to be in the Proportion (G2), Probability (G4), and Correlation (G5).

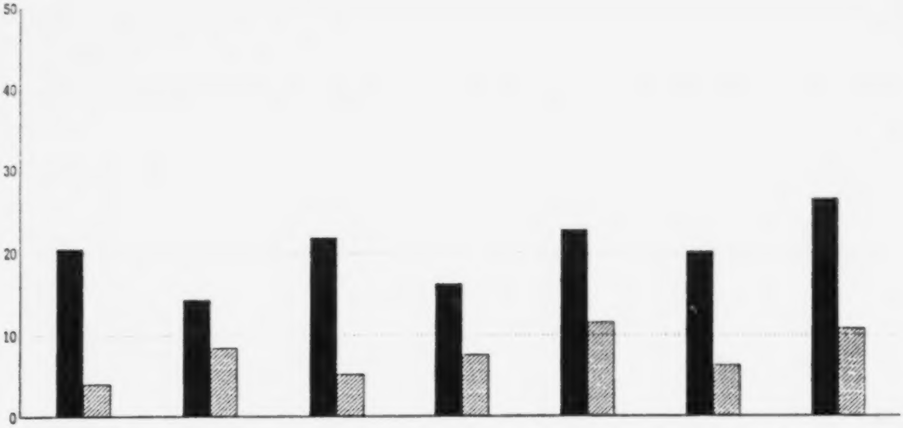
The data presented in Figure 67 suggest that more gain was



	G.T.	G1	G2	G3	G4	G5	G6
C-T	27.0	23.4	22.5	45.7	10.9	26.6	32.9
T-F	26.4	10.0	32.0	13.3	47.1	38.2	17.8

FIGURE 66

REVISED GALT SUBSCALES GAIN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY DEVELOPMENTAL LEVELS



	P.T.	P1	P2	P3	P4	P5	P6
C-T	20.5	14.4	21.8	16.3	22.8	20.2	26.5
T-F	4.0	8.5	5.3	7.7	11.6	6.3	10.8

FIGURE 67

POPS SUBSCALES GAIN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY DEVELOPMENTAL LEVELS attained by the pupils in the different process skills subscales during the concrete-transitional phase.

Comparing the reasoning and process skills results could bring about the idea that the process skills can develop altogether at a constant rate, while each reasoning skill exemplified different rate of development. Since each process subscale can be considered as related to the series of problem solving process within the classroom, thus making it possible to nurture them at the classroom setting. On the other hand, each of the reasoning subscales are known to related to the understanding of the concepts in which pupils operate inside the classroom. Each reasoning skill, therefore, requires the utilization of specific logical operation that can be influenced by the contents being introduced to them during the time of science instruction. Reasoning skills can be considered to be affected by the innate learning capacity of the learners.

B. VARIABLES RELATED TO THE PUPIL CHARACTERISTICS

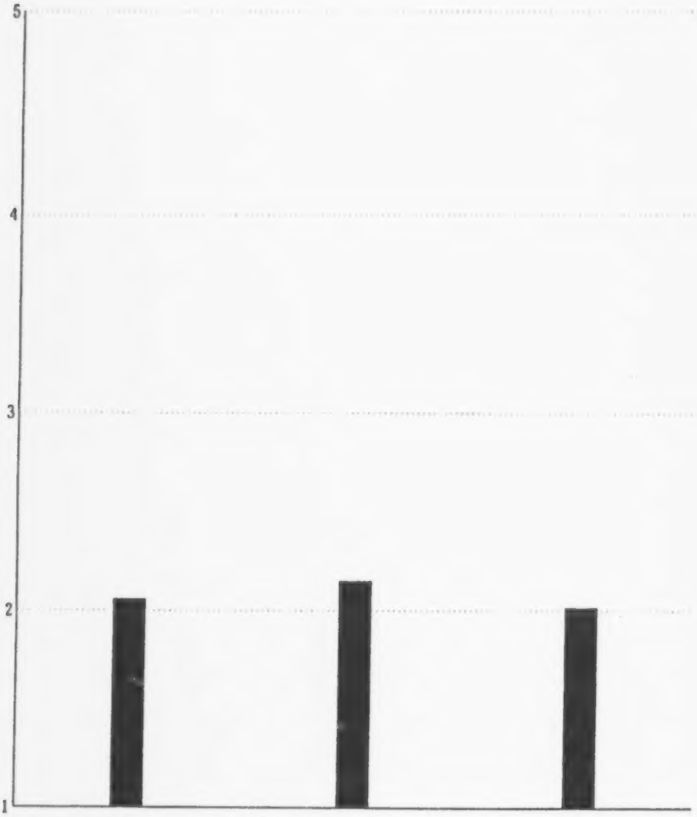
The variables related to the pupil charcateristics in Japan included the out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons. The analysis on these variables has been undertaken by means of comparing them with the results achieved by the secondary school students in Japan, which were descrived in the previous chapter of this study. The last discussion was made on the intercorrelation of the different pupil characteristics.

1. Out-of-School Science Experiences

The mean values of the out-of-school science experiences of the elementary school pupils in Japan were presented in Figure 68. It could be noted from the data that the experiences of the pupils seemingly have been categorized as within the 2 mark of the scale, which can be interpreted to have the meaning of rare experiences related to science out-of-school experiences. The scale of the figure can be analyzed by following this descriptiopn, to wit: Very Often, 5; Often, 4; Sometimes, 3; Rare, 2; and Never, 1. Although the male pupils seemed to have acquired more experiences than the female pupils, the expression can still be classified as rare. This condition of males having more experiences related to out-of-school science experiences than females was also true in the data taken from the secondary school students in Japan. This can be interpreted to be the result of the innate differences that exist between males and females with regard to the activities that has something to to with science. The males in Japan, can therefore be characterized to possess the innate capacity to like doing activities related to science courses. Teachers must therefore realize the fact that the differences of the activities related to science exist among the students as a result of their feminity and masculinity characteristics. Variety of experiences related to science should therefore be introduced by the teachers to all the pupils regardless of their gender so as to enable the commonality in the acquisition of various experiences.

The out-of-school science experiences mean in all items of the elementary school pupils in Japan by grade levels has been presented in graphical form in Figure 69. It could be noted from the data that the two groups acquired mean values that can be classified as within this rare category. However, a slight increase which has been statistically tested as significant has made the Grade 6 pupils to be considered as having more out-of-school science experiences than the Grade 5 pupils. It could be stated therefore that at this school level, that is elementary school level, the pupils in Japan tend to acquire more experiences related to science as they move upward of the educational ladder. However, if the data from the secondary school level would be compared to this data, the condition would be the opposite. The data taken in Japan from the secondary school level student depicted that they dealt with lesser experiences related to science while out of school.

The data taken from the elementary and secondary school levels presented the following mean values as found in each grade lelve, to wit: 2.04 for Grade 5, 2.13 for Grade 6, 2.06 for Grade 7, 1.91 for Grade 8, and 1.87 for Grade 9. An observable increase of the mean values exist when the data of the Grade 5 and Grade 6 pupils were to be scrutinized closely. On the other hand, the mean values acquired by the out-of-school science experiences analyzed as a whole seemed to show a decreasing tendency as the pupils move upward of the educational ladder. This could probably be explained by the fact that at the elementary school level in Japan, the introduction of out door experiences can be observed to exist commonly. The children are



Total	Male	Female
2.06	2.15	2.02

FIGURE 68

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN ALL ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX

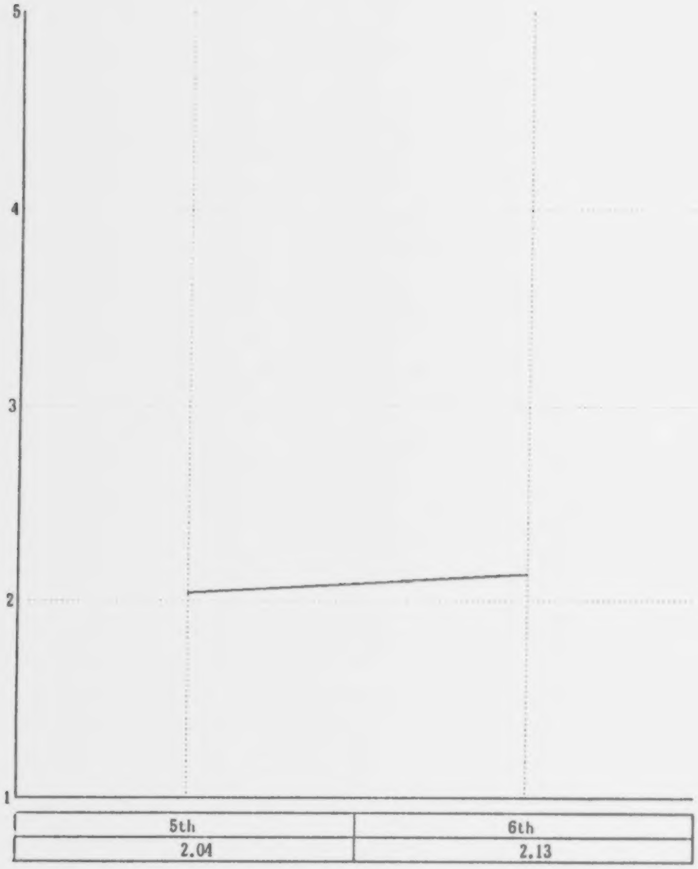
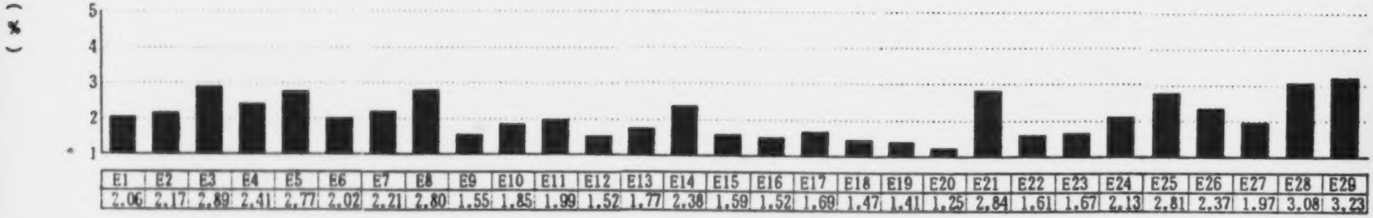


FIGURE 69

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN ALL ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL usually given homework to do related to science during their long vacation in between the term sessions yearly. A lot of places too, such as the youth study center, can be visited by the pupils at this school level.

The out-of-school science experiences means of the elementary school pupils in Japan by item have been presented in Figure 70. It could be noted from the data that the pupils seemingly were able to experience most of the activities at a rank known as rare. The science activities on "have experience in using woodwork or metal wor tools, eg. pliers, saw, planes, screwdriver, etc. (E28)," and "have experience in raising your favorite plants (E29)" acquired a mean rating that can be classified as sometimes because these had mean values of more than 3. The data for the secondary schools in Japan, however, suggest that the activities on "have experience in caring for rabbits, cats, dogs, or hamsters (E25)" has acquired the highest rating with 3.19 mean value that can be considered as higher than what it acquired from the elementary school pupils. The experiences that can be considered to have been dealt with rarely by the elementary school pupils included "visits to science museums, science centers (E1)," "visits to planetariums (E2)," "visits to libraries to read science books, magazines, etc. (E3)," "visits to marine science centers (E4)," "visits to the zoo (E5)," "visits to botanical gardens (E6)," "receives private tutoring in science and/or mathematics (E7)," "have experience in watching birds (E8)," "have experience in building model ships, cars or dollhouse (E14)," "watch TV science programs



E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25	E26	E27	E28	E29
2.06	2.17	2.89	2.41	2.77	2.02	2.21	2.80	1.55	1.85	1.99	1.52	1.77	2.38	1.59	1.52	1.69	1.47	1.41	1.25	2.84	1.61	1.67	2.13	2.81	2.37	1.97	3.08	3.23

FIGURE 70

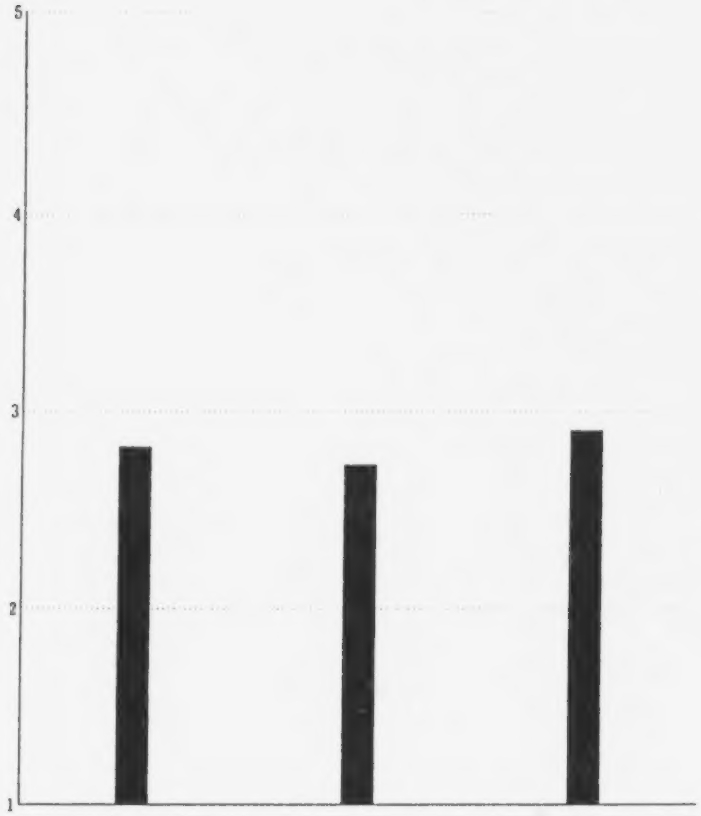
OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN
OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY ITEM

or listen to radio science programs (E21)," "have experience in caring for rabbits, cats, dogs, or hamsters (E25)," and "have experience in caring for fish (E26)." The science experiences that received the lowest mean values were on "participate in boy or girl scouting (E20)," "participate in special activities of science centers or museums (E19)," "takes paart in science club activities (E18)," "takes part in science fairs and contests (E16)," and "have experience in gathering rocks and fossils (E12)." It could be noted from the data that the activities in which the pupils have the least experiences seem to deal with various science club activities.

2. Motivation Towards Science Processes of the Pupils.

The data presented at this section were analyzed by using the following scales to interpret the mean values based on the ratings made by the pupils. The scale used incorporated the following scales: 5 for Strongly Motivated, 4 for Motivated, 3 for Undecided, 2 for Fairly Motivated, and 1 for Not Motivated at All. It should be noted that the motivation of the pupils were determined by usinsg a 15-item opinionnair containing various activities related to the science classes.

The data presented in Fiogure 71 exemplified the motivation towards science processes mean in all items of the elementary school pupils in Japan by sex. It could be noted from the data that the total of all the items accumulated a mean value of 2.82 which can be considered as exemplifying fair motivation to deal with the science activities. The female pupils acquired 2.90 mean value which has been statistically tested to be

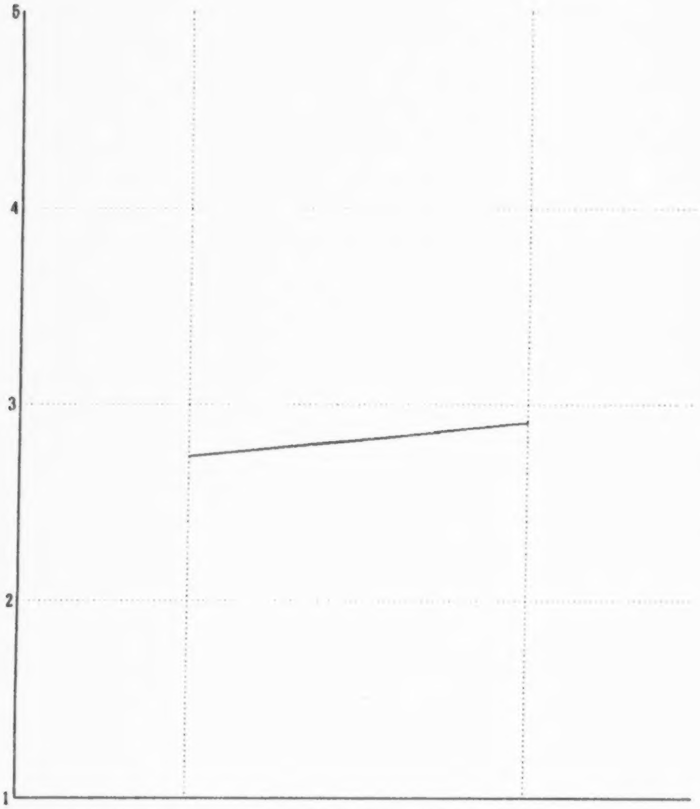


Total	Male	Female
2.82	2.73	2.90

FIGURE 71

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN IN ALL ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX significantly higher thatn the 2.73 mean value acauired by the male groups although both mean values were categorized as having shown fair motivation to perform the science tasks. Comparing the result found from the secondary school level, it could be stated that both groups did not show similarities in trend because the male groups acquired higher mean value than the females, although the difference was not significant, in the secondary school student groups. The females at the elementary school group, however, showed to have more positive motivation than the males. The secondary school sample showed that the females acquired 2.78 mean value, while the males acquired 2.90 mean value. The differences that existed between the results from the elementary school and secondary school could have demostrated the fact that the pupils commonly encounter variety of experiences as a result of the variation of educational environment, home environment, and societal environment as a result of their being at different age groups. This could be interpreted as the cause of inconclusiveness results in the 2 school groups.

The motivation towards science processes mean in all items of the elementary school pupils in Japan by grade level has been depicted in Figure 72. It could be noted from the data that significant difference between the mean values of the Grade 5 and Grade 6 pupils can be obtained. Extending the data up to the secondary school level would bring about the fact that the rising and falling tendency of the mean values can be observable. This condition could be illustrated by looking at the mean values

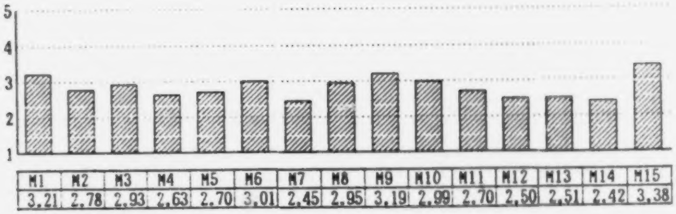


5th	6th
2.73	2.90

FIGURE 72

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN IN ALL ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL taken from each grade level which were shown as follows: 2.73 for Grade 5, 2.90 for Grade 6, 2.80 for Grade 7, 2.73 for Grade 8, and 2.78 for Grade 9. The data would therefore present the fact that the pupils acquired an increasing tendency of the mean values in Grade 6 and Grade 9. This trend could be interpreted as the result of the diversity in the methodology of science instruction being utilized by teachers at the different grade levels. In Japan, the existence of an examination to assess the knowledge acquired by the pupils as they reach Grade 9 can be observable, then the pupils enrolled prior to this grade level have to exert their educational efforts on mastering a lot of concepts in order to pass the examination. This would fact could be interpreted to have brought about an effect on the motivation of pupils to deal with the various science processes. On the other hand, the pupils at the elementary school levels encounter a lot of experiences in science classes that gives higher emphasis on observation and experimentation thereby making the motivation of the pupils increase as they move towards the higher grades. At the lower secondary school in Japan, the introduction of more formal science experiences occur through the lecture method and so less hands-on experiences could be availed of by them.

The motivation towards science processes mean of elementary school pupils in Japan by item can be seen in Figure 73. It could be noted from the figure that the pupils acquired a mean rating of more than 3 in items such as "working patiently on an investigation until the time you can arrive at a solution (M1),"



M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	M15
3.21	2.78	2.93	2.63	2.70	3.01	2.45	2.95	3.19	2.99	2.70	2.50	2.51	2.42	3.38

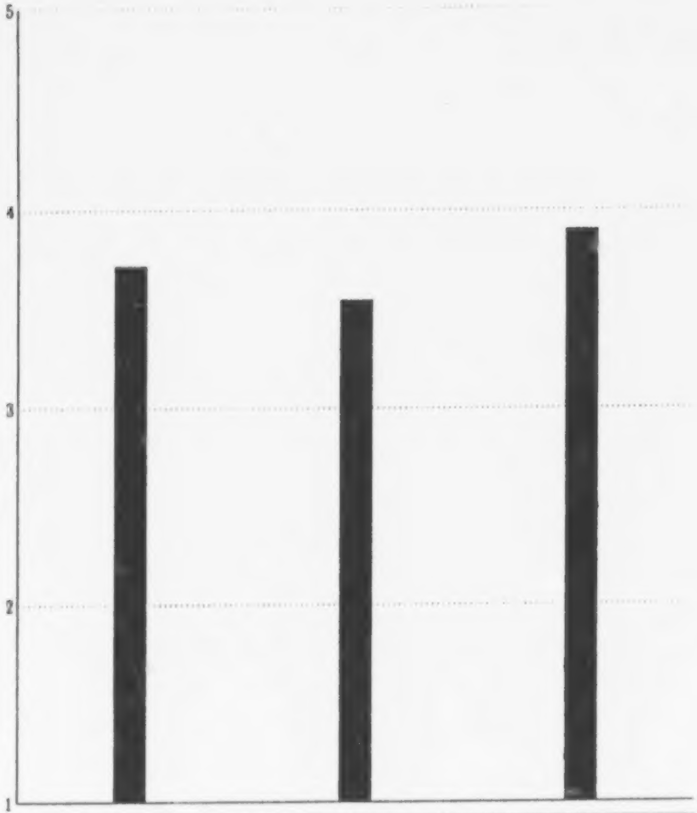
FIGURE 73

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY ITEM "getting involved in finding problems from the environment (M6)," "predicting, hypothesizing, inferring, etc. (M9)," and "cooperating with other students (M15)." The items that can be considered to be presenting commonality between the pupils of both elementary and secondary school samples in Japan, as to their having acquired the highest mean values, were on "working patiently on an investigation until the time you can arrive at a solution (M1)," and "cooperating with other students (M15)." It could be noted from the data presented that all the different processes were rated by the pupils at the elementary school level to be above the fairly motivated scale or 2. It must be stressed that the motivation of the pupils is directly related to the utilization of the processes that are considered by the learners to be challenging enough.

3. Love for Nature of Pupils

The love for nature of the elementary school pupils in Japan has been rated by using the scale comprizing of the following: 5 for Strongly Feel It, 4 for Feel It, 3 for Undecided, 2 for Fairly Feel It, and 1 for Feel Nothing. The different items of love for nature included "Beauty of Nature," "Greatness of Nature," "Respect for Life," and "Love for Nature."

The data presented in Figure 74 depicted the main ratings categorized according to the grade levels of the pupils. It could be noted from the data that the total love for nature has been given a main rating of 3.72 that can be considered to be very close to scale 4, meaning the pupils possessed the positive



Total	Male	Female
3.72	3.55	3.90

FIGURE 74

LOVE FOR NATURE MEAN IN ALL ITEMS
OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX

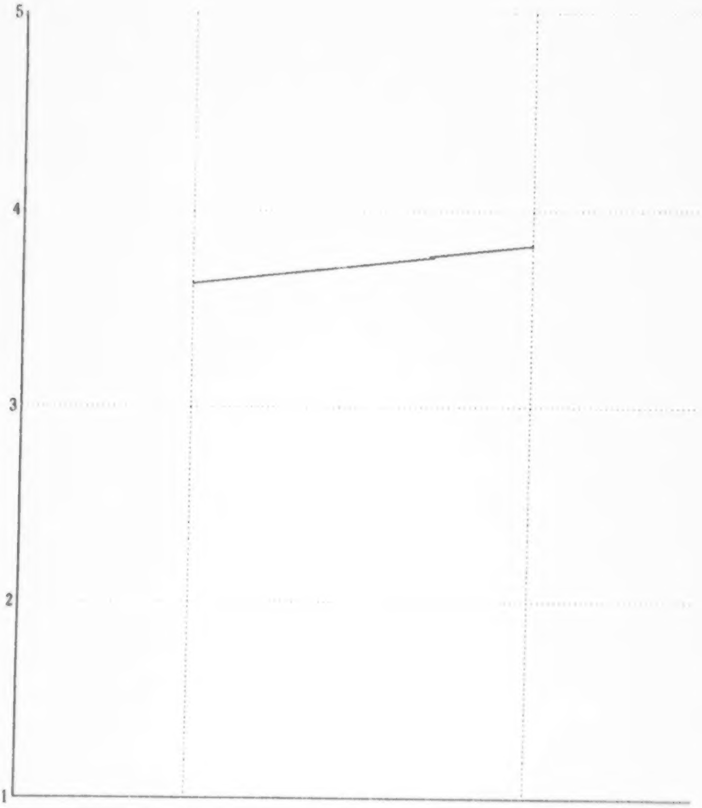
feeling towards love for nature. The females were also found out to have rated the love for nature items with 3.90 mean rating that can be interpreted that they feel the existence of love for nature. The males were able to rate the same with a lower mean value, which however, can also be classified to eximplify the fact that they also feel the existence of love for nature. The statistical analysis made suggest that a significant difference between the mean ratings provided by the females and the males has been found out.

Comparing the aforementioned results with the data taken from the secondary schools in Japan, it could be noted that the females were able to rate the love for nature higher than the ratings provided by the males. However, the female pupils from the secondary school levels were able to provide higher mean ratings than the elementary female pupils. Both groups however, had been found out to have shown positive love towards nature because the mean ratings they have provided were all above the 3.0 scale of the opinionnaire. The fact that the female groups of the elementary and secondary school samples were able to significantly provide a mean rating higher than the male groups suggest an innate difference between the members of the opposite sexes. The females have been found out to depict their having felt the love for nature.

The specific ratings that were provided by the students from the secondary school level in Japan were 3.85 for the males and 4.07 for the females. These ratings can be said to possess comparatively higher than the ratings made by their elementary school pupil counterparts as shown in Figure 74.

The love for nature mean in all items of the elementary school pupils in Japan by grade level has been presented in Figure 75. It was clearly depicted in the figure that the Grade 6 pupils were able to rate the items higher than the ratings made by the Grade 5 pupils. The difference has been tested to have shown significance. If the data taken ffrom the secondary school level were to be compared, the tendency of the mean ratings provided by the pupils from Grade 5 to Grade 9 would project a pattern that possess an upward and downward direction depicted by the mean ratings which are shown as follows* 3.63 for Grade 5, 3.82 for Grade 6, 3.95 for Grade 7, 3.88 for Grade 8, and 4.05 for Grade 9. If the sequence were to be analyzed closely, the development of love for nature of the learners seemed to have developed positively along with the advancement of the pupils from the lower grades to the upper grades, and then later subsided slightly at a certain level which actually gained an increase a the next higher level again. So an increasing mean value has been arrived at in between Grade 5 and Grade 7, but a decline has been depicted by the Grade 8 pupils. The declining tendency of the ratings provided by the Grade 8 pupils has been counter balanced by the increasing tendency of the ratings provided by the Grade 9 pupils on their feeling towards love for nature.

This condition can be observable in Japan, even though both levels are considered to be within the compulsory education, because of the differences of the curricular offerings being



5th	6th
3.63	3.82

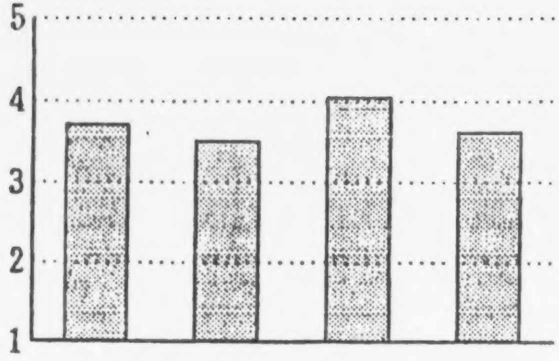
FIGURE 75

LOVE FOR NATURE MEAN IN ALL ITEMS
OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL

provided to pupils at these school levels. At the secondary school level, in which the samples of the study were taken, the utilization of teaching procedures that made use of emphasizing pure disciplines can be observable, and that teachers commonly emphasize the importance of knowledge and understanding of science concept per se. It can be observable from the data presented that the love for nature of the learners, which is an affective domain of learning, has also been developed. It would therefore be possible to foster the acquisation of a positive love for nature within the science classroom. Teachers should therefore value the fact that intelectual developm,ent is affected by the affective phase of the learners.

The love for nature mean values of the elementary school pupils in Japan by item were depicted in Figure 76. It could be observable from the data that the different love for nature items were rated to have been felt by the elementary school pupils used as samples in the study. It could be noted from the data that Respect for Life (L3) has been rated by the pupils with a value of 4.05. It was followed by Beauty of Nature (L1) with 3.70 and Love for Nature (L4) with 3.60. The item that acquired the lowest mean rating was on Greatness of Nature (L2) with a mean value of 3.53. It could be noted, however, that all of these ratings were all above 3.0 as shown in the figure. This tendency of having a rating of one 3.0 of all the love for nature items also exist in the data takem from the secondary school students in Japan.

The fact that the love for nature has been considered a



L1	L2	L3	L4
3.70	3.53	4.05	3.60

FIGURE 76

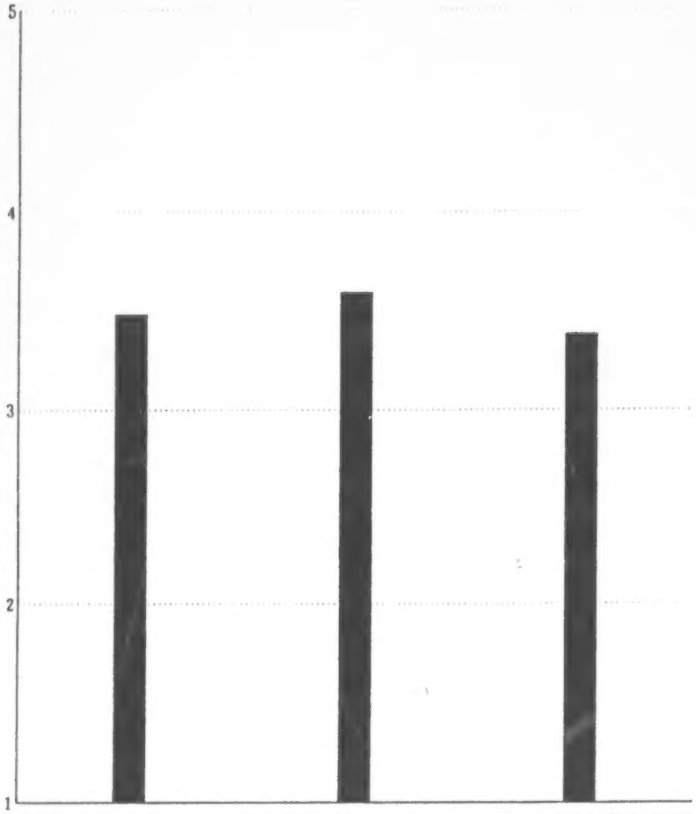
LOVE FOR NATURE MEAN
OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY ITEM

common tendency of the pupils at the elementary and those at the secondary school levels suggest that the feeling to love nature is a common phehomena for both groups of learners. Since science dealt on topic that has direct relationship to the nature, then the objective in science teaching in Japan which encourages the acquisition of the learners of loving nature can be considered an important factor in order to facilitate the learning interest of the pupils. The beauty of nature, greatness of nature, respect for life, and love of nature are just some of the examples of the emotional feelings that must be nurtured among the learners at the different school levels.

4. Attitude Towards Science Lessons

The attitude towards science lessons mean values of the elementary school pupils in Japan has been gathered by using a 20-itemn opinionnaire that possessed various attitudinal statements commonly experience within a science classroom. It should be emphasized that the scale that was used by the samples included the following calibrations, to wit* 5 for Strongly Agree, 4 for Agree, 3 for Undecided, 2 for Disagree, and 1 for Strongly Disagree. The ratings made by the elementary school pupils were also compared to the responses made by the secondary school pupils in Japan.

The attitude towards science leassons mean values in all items of the elementary school pupils in Japan by sex has been presented in Figure 77. It could be observable from the data that the males and females were both having a positive attitude toward the science lesssons. It could be stated further,



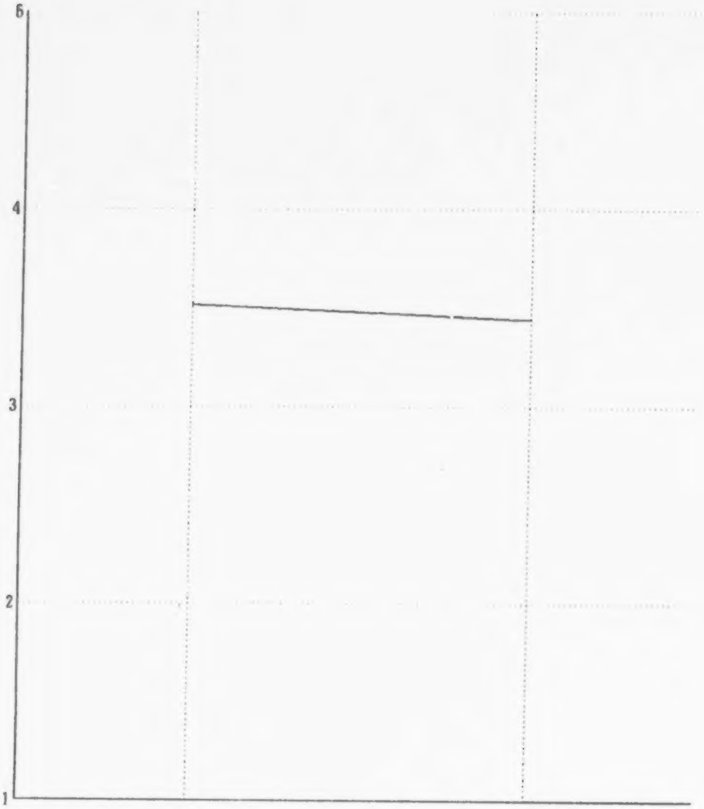
Total	Male	Female
3.48	3.59	3.38

FIGURE 77
ATTITUDE TOWARDS SCIENCE LESSONS MEAN IN ALL ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX

however, that the males acquired a significantly higher positive attitude than the females. Comparing the data to the ratings made by the secondary school students would confirm the fact that the elementary pupils were able to acquire higher positive attitude toward science lessons than their counterparts. The data from the secondary school depicted that the attitude mean of males was 3.38, the the females acquired 3.06.

It could be stated however, after comparing the results, that both school levels acquired data that favored the male pupils on having felt a positive attitude toward science lesson over the females. This could be interpreted as caused by incidental factors such as the effect of educational environment. The expectation of parents as well as teachers that pupils should try their best to achieve in science could be a strong factor that affected the positive attitude of pupils toward science lessons.

The attitude towards science lesson mean in all items of elementary school pupils in Japan by grade level has been presented in Figure 78. It could be noted from the data that the elementary school pupils tend to acquire negative attitude towards science lessons as they go upward the next higher grade level, although the decline can still be classified as a positive attitude. In order to extend the view about the attitude of pupils towards science, the data from the secondary school students would also be presented. It could be noted from the data that the pupils from Grade 5 to the learners of Grade 9 acquired the following mean ratings as to their attitude towards



5th	6th
3.52	3.45

FIGURE 78

ATTITUDE TOWARDS SCIENCE LESSONS MEAN IN ALL ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE LEVEL science lessons, to wit: 3.52 for Grade 5, 3.45 for Grade 6, 3.35 for Grade 7, 3.14 for Grade 8, and 3.19 for Grade 9. All of these attitude mean values can be interpreted as positive. However, as the learners move to the higher grades, in general, they tend to demonstrate a declining tendency of their positive attitude towards science lessons. This could probably be explained by the fact that in Japan, as the pupils go upwards to the other educational levels, the introduction of more formal concepts during regular class hours become so predominant thereby decreasing the experience of the learners in various laboratory activities. The emphasis has therefore been changed from the laboraroty oriented activities into memorizing knowledge or learning by rote. At the end of Grade 9, it is also observable in Japan that the pupils are expected to coup with activities related to the examination that is awaiting for them. The examination being given to the pupils at the time they reach the Grade 9 has therefore given a lot of pressure on the part of the learners as well as the other people around them.

5. Intercorrelation Among the Pupil Characteristics in Japan

The intercorrelation of the different pupil characteristics in Japan such as the out-of-school science experiences, motivation towards science processes, attitude towards science lessons, and love for nature has been discussed so that an understanding on how these variables could be used altogether to improve the science teaching and learning process.

It can be gleaned in Tabel 38 that the highest positive correlation coefficient existed between Motivation Towards Science Processes variabale and the Love for Nature variable that brought about a value of .57. The positive correlation coefficient that has been computed was between Out-of-School Science Experiences variable and Motivation Toward Science variable with a value of .55. The lowest correlation that was calculated with a value of .28 has been between Love for Nature variable and the Attitude Towards Science variable. It could be noted, however, that all of the correlation coefficients were showing positive significant values which were all more than a value of .20. These different variables related to the characteristics of the pupils have therefore been statistically tested to be having positive correlation that were significant.

The summary diagram of the correlation analysis among the selected pupils charcateristics variables of the elementary pupils in Japan has been presented in Figure 79. This schematic diagram can clearly illustrate the intercorrelation of the variables such as the out-of-school science experiences, motivation towards science processes, attitude toward science lessons, and love for nature. All the variables, as was mentioned earlier, can be found out to have correlation to the other values of over .20. These high correlation coefficients as exemplified by the diagram follow a pattern similar to the data taken from the secondaary school students in Japan. The students from the secondary schools in Japan also were able to respond to the opinionaire with values on out-of-school science experiences, motivation towards science processes, attitude towards science

TABLE 38

CORRELATION MATRIX IN OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, ATTITUDE TOWARDS SCIENCE LESSONS AND LOVE FOR NATURE OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Experience	Motivation	Love	Attitude
Science Experience Out of School		.55***	.34***	.35***
Motivation toward Science Processes			.57***	.39***
Love for Nature				.28***
Attitude toward Science Lessons				

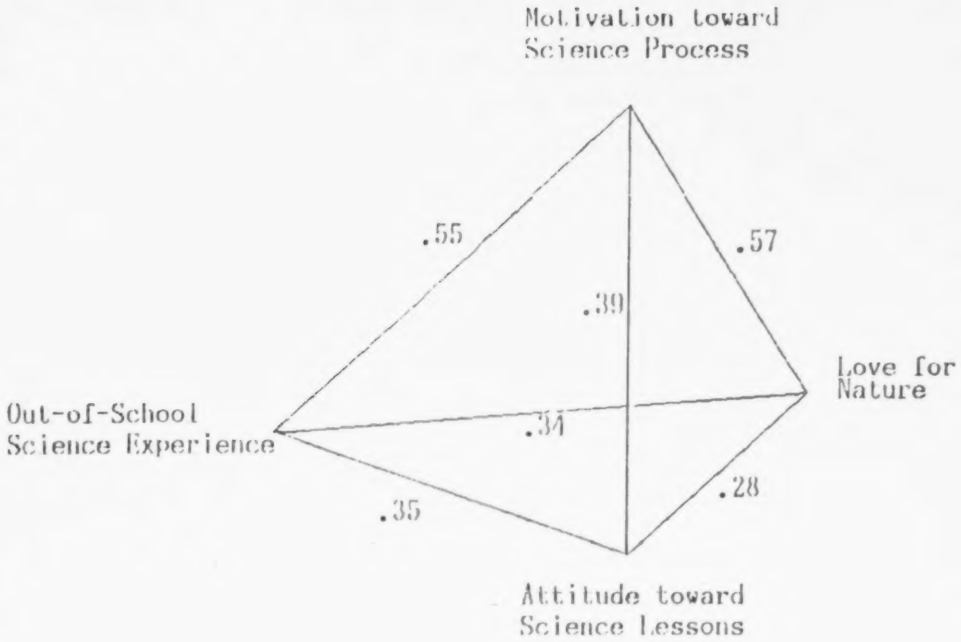

Motivation toward
Science Process
.55
.57
.39
Love for
Nature
Out-of-School
Science Experience
.34
.28
.35
Attitude toward
Science Lessons

FIGURE 79

SUMMARY DIAGRAM OF CORRELATION ANALYSIS AMONG
SELECTED VARIABLES OF THE ELEMENTARY SCHOOL PUPIILS IN JAPAN

lessons, and love for nature variables that brought about high correlation coefficients. The fact that these variables possess high intercorrelationships suggest that teachers must provide a lot of experiences for the learners in various out-of-school science activities as well as provide them chances to develop their love for nature so that the variables that are oftenly affected by classroom instruction, such as motivation towards science processes and attitude towards science lessons could also be developed.

C. PUPIL CHARACTERISTICS AS RELATED TO SCIENTIFIC THINKING

The relationship of the various pupil characteristics used in this study such as the out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons to the scientific thinking skills has been calculated in this study. It is important to know the extent of the effect of these variables to the scientific thinking skills because measures could be done in order to improve their utilization within a science classroom. Specifically, the scientific thinking skills would include both reasoning and process skills in science.

1. Relationship of Out-of-School Experiences to Scientific Thinking Skills

The analysis of variance results on the effect of out-of-school science experiences variable to the performance of pupils in reasoning and science process skills has been presented in Table 39. It could be noted from the data that not all of the 29 items of the out-of-school experiences in which the pupils have dealt with were having significant relationship to the reasoning and process skills performance.

The data from the section related to the effect of the experiences of the pupils to their reasoning skills performance suggest that items such as "visits to science museums, science centers (1)," "visits to marine science centers (4)," "visits to botanical gardens (6)," "participate in boy or girl scouting (20)," "have experience in using microscope (22)," "have experience in examining and repairing electrical appliances (27)," and "have experience in using woodwork or metal work tools e.g. pliers, saw, planes, screwdrivers, etc. (28)" acquired significant relationships. All these items were also found out to be significant in the data takem from the secondary schools in Japan. The calculated relationships has also brought about a value which suggest that the out-of-school experiences of the learners in total at the elementary school level relate significantly to the reasoning skills total.

The section for the science process skills as related to the experiences in science available outside of the school that the pupils at the elementary school levels in Japan were able to avail of as shown in Table 39 suggest that the significant relationship has been calculated between the total out-of-school experiences and the science process skills performance of the pupils. The items that related significantly to the process skills in science performance of the pupils were "visits to science museums, science centers (1)," "visits to libraries to read science books, magazines, etc. (3)," "visits to marine

TABLE 39

ANALYSIS OF VARIANCE MATRIX IN REVISED GALT AND POPS SUBSCALES AND OUT-OF-SCHOOL SCIENCE EXPERIENCES ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Reasoning Skills All: df=116 Each: df= 4	Process skills All: df=116 Each: df= 4
Total	2.26••	2.57••
1	8.78••	9.14••
2	2.03NS	0.58NS
3	7.57••	6.99••
4	4.64••	3.07•
5	1.85NS	1.98NS
6	2.43•	1.51NS
7	0.94NS	0.65NS
8	1.31NS	1.05NS
9	1.50NS	2.01NS
10	0.91NS	0.50NS
11	0.68NS	3.85••
12	1.27NS	2.57•
13	0.71NS	0.54NS
14	0.83NS	4.39••
15	0.32NS	1.00NS
16	1.00NS	2.56•
17	0.85NS	2.36NS
18	1.39NS	2.34NS
19	1.95NS	3.91••
20	3.55••	4.02••
21	1.90NS	0.68NS
22	3.42••	3.64••
23	2.15NS	2.35NS
24	2.10NS	1.88NS
25	2.16NS	1.37NS
26	0.97NS	1.55NS
27	2.75•	3.43••
28	4.11••	2.12NS
29	1.61NS	2.64•

science centers (4)," "have experience in gathering plants, leaves and flowers (11)," "have experience in gathering rocks and fossils (12)," "have experience in building model ships, cars, or dollhouse (14)," "participate in special activities of science centers or museums (19)," "have experience in using microscopes (22)," "have experience in examining and repairing electrical appliances (27)," and "have experience in raising your favorite plants (29)."

Looking at the data related to the relationships of the out-of-school science experiences in both scientific skills would suggest that the following items have been found out to have significantly related to both scientific experiences. The items were as follows: "visits to science museums, science centers (1)," "visits to libraries to read science books (3)," "visits to marine science centers (4)," "participate in boy or girl scouting (20)," "have experience in using microscopes (22)," and "have experience in examining and repairing electrical appliances (27)." The fact that these experiences related to both process skills and reasoning skills of the elementary school pupils in Japan could provide to the teachers an idea that to nurture both scientific thinking skills, common experiences related to science that can be availed of by the pupils could be utilized to improve further the process of teaching and learning at this school level.

2. Relationships of Motivation Towards Science Processes and Scientific Thinking Skills

The analysis of various matrix of the effect of motivation towards science to the reasoning and process skills in science performance of the elementary school pupils in Japan can be seen in Table 40.

It could be noted from the data that the total motivation towards science processes walue significantly brought about a relationship to the total reasoning skills. The motivation towards science the pupils possessed could therefore be interpreted as having an effect on the performance on the reasoning skills. It could be noted from the data that out of the 15 items of the opinionnaire on the motivation towards science processes, 9 items have been found out to possess significant relationship to the reasoning skills. The items that possessed significant relationship to the reasoning skills were "working patiently on an investigation until the time you can arrive at a solution (1)," "carrying out an investigation using only the available facts (2)," "devising a new method of observing and experimenting (3)," "thinking logically and critically (4)," "getting involved in data collection (5)," "predicting, hypothesizing, inferring, etc. (9)," "recording data (10)," "applying findings to new problems (14)," and "cooperating with other students (15)." Comparing the results to the data taken from the secondary school students in Japan suggest that all the items mentioned above also related to the reasoning skills with the exception of items 14 and 15.

The section on the relationships that exist between the total motivation towards science processes and total process skills in science suggest that a significant relationships with a value4 of 4.99 has been attained. The motivation towards science processes of the elementary pupils therefore could affect their performance on the science process skills. The items that related to the science process skills included "working patiently on an investigation until the time you can arrive at a solution (1)," "carrying out an investigation using only the available facts (2)," "devising a new method of observing and experimenting (3)," "thinking logically and critically (4)," "getting involved in data collection (5)," "predicting, hypothesizing, inferring, etc. (9)," "interpreting data (12)," "applying findings to new problems (14)," and "cooperating with other students (15)." Comparing this result to the data taken from the secondary school students in Japan would bring about the fact that item 12 and 15 have been found out to be common in the two school levels.

The data from Table 40 further presented the fact that the items such as "working patiently on an investigation until the time you can arrive at a solution (1)," "carrying out an investigationg using only the available facts (2)," "devising a new method of observing and experimenting (3)," "thinking logically and critically (4)," "getting involved in data collection (5)," and "predicting, hypothesizing, inferring, etc." were found out to be significant in both reasoning and process skills in science. This finding can also be stated as consistent to what has been found out using the data coming from the secondary school students in Japan, Republic of Korea, United States and the Philippines.

TABLE 40

ANALYSIS OF VARIANCE MATRIX IN REVISED GALT AND POPS SUBSCALES AND MOTIVATION TOWARDS SCIENCE PROCESSES ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Reasoning Skills All: df= 60 Each: df= 4	Process skills All: df= 60 Each: df= 4
Total	3.83**	4.99**
1	14.04**	17.63**
2	7.34**	11.01**
3	7.87**	11.89**
4	4.01**	3.23*
5	3.47**	7.67**
6	2.29NS	1.77NS
7	0.16NS	0.53NS
8	1.45NS	1.94NS
9	4.44**	4.85**
10	3.57**	0.81NS
11	0.70NS	0.30NS
12	0.61NS	2.48*
13	0.24NS	0.69NS
14	2.76*	7.30**
15	4.48**	2.73*

3. Relationships of Love for Nature and Scientific Thinking Skills

The relationship of the love for nature possessed by the pupils to their performance in the reasoning and science process skills can be seen in Table 41. It could be noted from the data that the total love for nature value has significant relationships to the total of reasoning skills and to the total of the process skills in science. It could also be noted further that all the relationships of the items of love for nature to the reasoning skills have been found out to be significant. This finding has been found out to be the same with what the data from the secondary schools in Japan has brought about. The different items of love for nature such as "Beauty of Natue (1)," "Greatness of Nature (2)," "Respect for Life (3)," and "Love of Nature (4)" can be considered as having affected the performance of the pupils in reasoning skills.

The data presented in Table 41 further suggest that all the love for nature items, with the exception of "Love of Nature (4)," have been found out to possess effect on the performanc of the elementary pupils in reasoning. Similar findings have also been arrived at using the data from the secondary schools in Japan.

The items that have relationships that are significant to both reasoning and science process skills were "Beauty of Nature (1)," "Greatness of Natue (2)," and "Respect for Life (3)."

4. Relationships of Attitude Towards Science Lessons and Scientific Thinking Skills

TABLE 41

ANALYSIS OF VARIANCE MATRIX IN REVISED GALT AND POPS SUBSCALES AND LOVE FOR NATURE ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Reasoning Skills All: df= 16 Each: df= 4	Process skills All: df= 16 Each: df= 4
Total	6.31••	9.96••
1	8.27••	17.40••
2	10.60••	15.95••
3	2.66•	5.08••
4	3.69••	1.42NS

The relationships of the attitude towards science lessons possessed by the pupils to the scientific thinking skills such as reasoning and science process skills has been presented in Table 42. It could be noted from the data that the total of the attitude towards science has significantly acquired a relationship to the total of reasoning skills and to the total of science process skills.

Specifically, the items of the attitude towards science lessons that significantly related to the reasoning skills were "I am always under a terrible strain in a science class (1)," "I do not like science and it scares me to have to take it (2)," "science is very interesting to me and I enjoy science courses (3)," "my mind goes blank and I am unable to think clearly when working in science (6)," "the feeling that I have toward science is good feeling (9)," "science is something which I enjoy a great deal(11)," "I really like science (14)," and " I am happier in a science class than in any other class (18)." This result resembles the findings arrived at using the data from the secondary schools in Japan except that item 11 has not been found out to be common.

The data in Table 42 further suggest the fact that the following items of the attitude towards science lessons which consisred of "I am always under a terrible strain in a science class (1)," "I am always under a terrible strain in a science class (1)," "I do not like science and it scares me to have to take it (2)," "science is very interesting to me and I enjoy science courses (3)," "I feel a sense of insecurity when

TABLE 42

ANALYSIS OF VARIANCE MATRIX IN REVISED GALT AND POPS SUBSCALES AND ATTITUDE TOWARDS SCIENCE LESSONS OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Reasoning Skills All: df= 80 Each: df= 4	Process skills All: df= 80 Each: df= 4
Total	2.69••	2.78••
1	6.60••	2.46•
2	7.28••	12.39••
3	9.30••	8.79••
4	1.10NS	1.75NS
5	1.55NS	0.71NS
6	2.94•	2.29NS
7	2.01NS	3.89••
8	3.71••	4.07••
9	2.62•	2.34NS
10	0.38NS	0.07NS
11	2.89•	1.62NS
12	1.95NS	2.08NS
13	1.31NS	0.90NS
14	2.81•	1.49NS
15	0.85NS	3.24•
16	0.58NS	1.45NS
17	1.23NS	3.11•
18	2.42•	1.94NS
19	2.05NS	0.27NS
20	0.23NS	0.71NS

attempting science (7)," "science makes me feel uncomfortable, restless, irritable, and impatient (8)," "science is a course in school which I have always enjoy studying (15)," and "I have never liked science and it is my most dreaded subject (17)," were found out to have possessed significant relationships to the process skills in science.

It could be noted further from the data that the following items of attitude towards science lessons related significantly to both reasoning and process skills, to wit: "I am always under a terrible strain in a science class (1)," "I do not like science and it scares me to have to take it (2)," "science is very interesting to me and I enjoy science courses (3)," and "science makes me feel uncomfortable, restless, irritable, and impatient."

4. Relationships and Correlations of the Scientific Thinking Skills and the Student Characteristics

The data previously presented suggest that the total reasoning skills and total process skills in science possessed a significant relationships with the total value of the out-of-school science experiences, motivation towards science processes, attitude towards science lessons, and love for nature of the elementary school pupils in Japan. At this section of the study, the relationships existing between the pupil characteristics and the different subscales of reasoning and process skills would be analyzed. The correlations among these variables would also be discussed at this section.

The analysis of variance and correlation coefficient matrix of the revised reasoning subscales and the pupil characteristics are presented in Table 43. It could be noted from the data that the GALT total and all the reasoning subscales were found out to have significantly related in all of the 4 variables with the exception of "Correlational Reasoning" and "Attitude Towards Science Lessons" based on the analysis of variance coefficient achieved. It could also be noted that through the correlation analysis that the "Out-of-School Science Experiences" have not been found out to correlate significantly with Controlling Variables (G3) and Combinatorial Reasoning (G6). The "Love for Natue" possessed by the pupils brought about a correlation coefficient that was not significant with Probabilistic Reasoning (G4) and Combinatorial Reasoning (G6). The "Love for Nature" possessed by the pupils brought about a correlation coefficient that was not significant with Probabilistic Reasoning (G4). The highest correlation among the GALT Total and the different pupil characteristics was on "Motivation Towards Science Processes" which brought about a significant correlation coefficient of .21.

The relationships as well as the correlations of the process skills and the pupil characteristics of the pupils in Japan were presented in Table 44. It could be noted from the data that all the process skills were related to all the 4 pupil characteristics with the exception of Graphing Data (P5) and "Attitude Towards Science Lessons." With regards to the correlation, it could also be observed that all process skills corelated significantly to all the pupil characteristics with the exception of Identifying Experimental Questions (P1) and "Out-of-School Science Experiences." The process skills total and the

TABLE 43

ANALYSIS OF VARIANCE AND CORRELATION COEFFICIENT MATRIX IN EACH REVISED GALT SUBSCALE AND OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, ATTITUDE TOWARDS SCIENCE LESSONS AND LOVE FOR NATURE OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Science Experience Out of School		Motivation toward Science Processes		Love for Nature		Attitude toward Science Lessons	
	F (df=116)	r	F (df= 60)	r	F (df= 16)	r	F (df=80)	r
GALT Total	2.26**	.09***	3.83**	.21***	6.31**	.14***	2.69**	.16***
G1: Conservation	1.63**	.09***	2.53**	.13***	2.51**	.09***	2.07**	.15***
G2: Proportional Reasoning	1.66**	.07**	2.12**	.12***	2.76**	.07***	1.38*	.08***
G3: Controlling Variables	1.43**	.02NS	2.13**	.15***	3.58**	.12***	2.13**	.10***
G4: Probabilistic Reasoning	1.37**	.05*	1.73**	.11***	2.22**	.03NS	1.30*	.05*
G5: Correlational Reasoning	1.45**	.07**	1.70**	.09***	2.30**	.06**	1.25NS	.10***
G6: Combinatorial Reasoning	1.78**	.03NS	1.76**	.11***	3.12**	.09***	1.48**	.08***

TABLE 44

ANALYSIS OF VARIANCE AND CORRELATION COEFFICIENT MATRIX IN EACH POPS SUBSCALE AND OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARDS SCIENCE PROCESSES, ATTITUDE TOWARDS SCIENCE LESSONS AND LOVE FOR NATURE OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Science Experience Out of School		Motivation toward Science Processes		Love for Nature		Attitude toward Science Lessons	
	F (df=116)	r	F (df= 60)	r	F (df= 16)	r	F (df=80)	r
POPS Total	2.57••	.08•••	4.99••	.26•••	9.96••	.23•••	2.78••	.18•••
P1: Identifying Experimental Questions	1.69••	.00NS	1.89••	.12•••	4.18••	.13•••	1.93••	.11•••
P2: Identifying Variables	2.36••	.07••	3.94••	.23•••	7.14••	.21•••	2.27••	.15•••
P3: Formulating Variables	1.64••	.07••	2.16••	.17•••	4.26••	.15•••	1.49••	.11•••
P4: Designing Investigations	1.67••	.08••	3.85••	.23•••	7.01••	.20•••	1.87••	.13•••
P5: Graphing Data	1.38••	.06•	1.75••	.12•••	3.27••	.11•••	1.02NS	.07••
P6: Interpreting Data	1.63••	.06•	2.73••	.19•••	4.01••	.12•••	2.03••	.17•••

Identifying Variables (P2) and Designing Investigations (P4) possessed relatively high correlation to pupil variables such as in "Motivation Towards Science Processes" and "Love for Nature." The process skills in science tend to accumulate relatively high to the 4 pupil characteristics more than that of the reasoning skills. This same result has also been found out in the secondary school students data takem from the 4 countries as was shown in the previous chapter of this study.

Concluding Remarks

It has been found out in this section of the research that the elementary school pupils in Japan tend to show acquisition of better reasoning skills and science process skills as they move from lower grade towards the higher grade levels. However, the different pupil characteristics such as the out-of-school science experiences, attitude towards science lessons, motivation towards science processes, and lover for nature seemed to have shown various patterns.

The out-of-school science experiences of the pupils followed an increasing pattern as the elementary pupils in Japan progress in their grade levels. The higher the grade level of the pupils therefore would mean their having acquired more science experiences while out of school. It the data from the secondary school level in Japan would be used as extension, however, a declining tendency can be observable wherein the students enrolled in the higher grade levels tend to possess lesser out-of-school science experiences.

The motivation towards science processes possessed by the pupils at the elementary grade levels tend to increase as they move to the higher grade levels. A tendency of a sligjt decline when the pupils get into the first 2 years of the secondary school level if the data from these grade levels would be added. However, the declining tendency of the secondary school students can be observed to increase again as the pupil move to the last lyear at the lower secondary school levels in Japan.

The love for nature in which the pupils at the elementary school pupils in Japan possessed had been found out to increase along with the advancement of grade level. So the Grade 6 pupils were found out to have rated their love for nature higher than those of the Grade 5 pupils. Extending this result to the secondary school level data taken in Japan suggest that a rising pattern on the mean ratings provided by the learners advancement to the next higher grades.

The attitude toward science lesson in which the pupils at the elementary school in Japan possessed has been found out to decrease as they advance in the upper grade levels. The data taken from the secondary school levels in Japan would further corroborate with this finding because the students at this level were found out to have exemplified the similar pattern. It seems, therefore, that the attitude of the subjects from the elementary and secondary school levels in Japan would decrease as they move upward in their educational grade level.

As shown in Figure 80, the different pupil characteristics such as the out-of-school science experiences, motivation towards science, love for nature, and attitude towards cience lessons significantly correlated to both the reasoning and science process skills. The relationships have also proved values considered as significant. The various pupil characteristics were therefore affecting the scientific thinking skills of the learners in Japan at the elementary school level. The highest correlation values calculated were on Motivation Towards Science Process and to both the reasoning and science process skills. The Love for Nature has also exemplified a high correlation with the process skills in science.

The need of data that could support the effect of the affective domain toward the cognitive domain of learning, or vise versa, is needed in order to understand the effectiveness of a science program. It is also an important idea to determine the effect of the out-of-school science experiences of the pupils toward the promotion of the development of cognitive skills. In Japan, almost half of the pupils enrolled at the elementary school levels enroll to the after school institutions known as "Yobiko" or "Juko." At the period of the first 3 years of the secondary school, the lower secondary school level in Japan, approximately 60 % of the students enroll to the after school institutions too. The existence of these institutions may be interepreted too as another source of additional activities for the students, while out-of-school, which can therefore be interpreted also to have provided additional knowledge that might be helpful in developing the cognitive capacity of the learners.

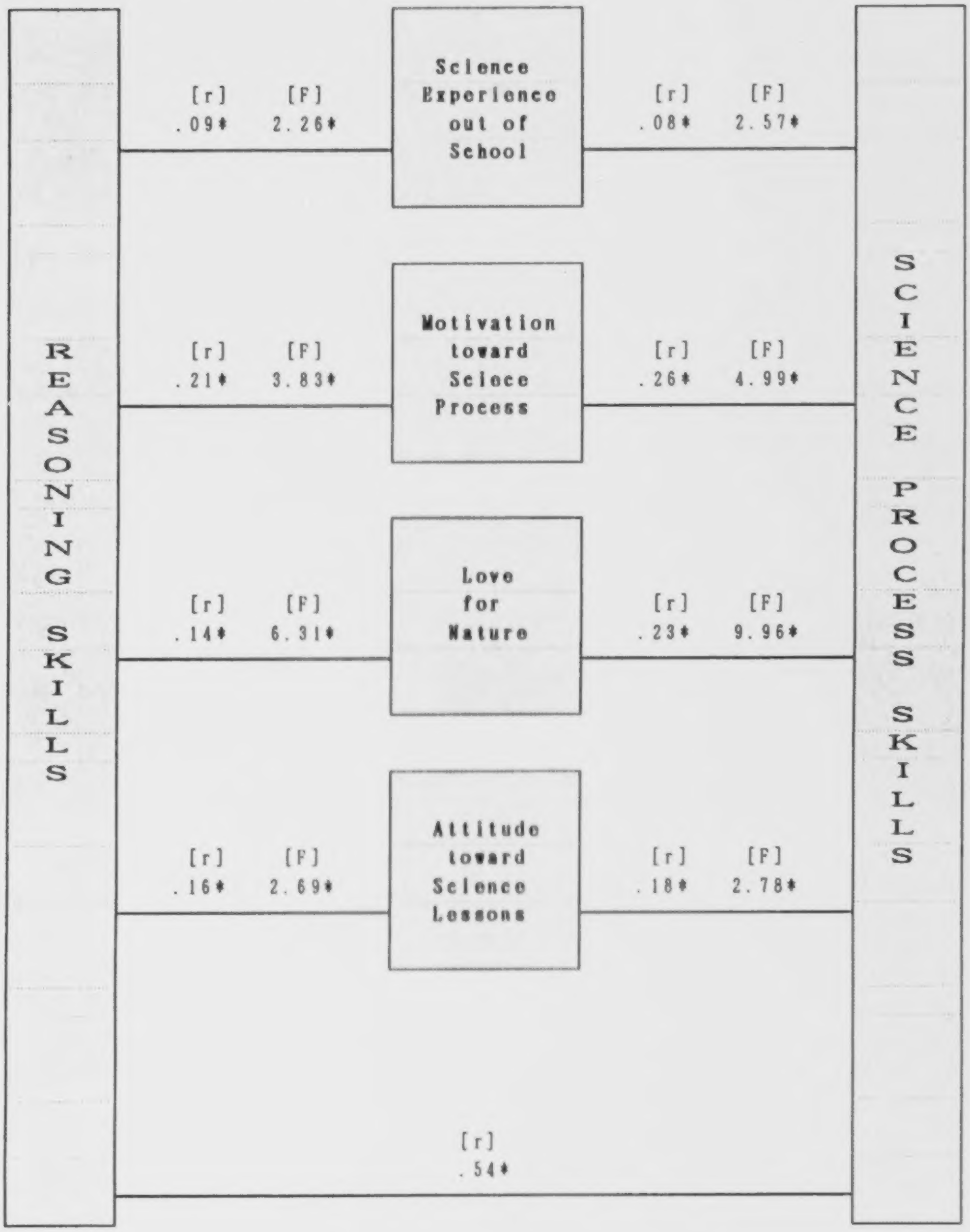

REASONING SKILLS
Science Experience out of School
[r] .09* [F] 2.26*
[r] .08* [F] 2.57*
Motivation toward Scioce Process
[r] .21* [F] 3.83*
[r] .26* [F] 4.99*
Love for Nature
[r] .14* [F] 6.31*
[r] .23* [F] 9.96*
Attitude toward Science Lessons
[r] .16* [F] 2.69*
[r] .18* [F] 2.78*
[r] .54*
SCIENCE PROCESS SKILLS

FIGURE 80

SUMMARY DIAGRAM OF CORRELATION ANALYSIS AND MULTIPLE ANALYSIS OF VARIANCE CONCERNING THINKING SKILLS AND SELECTED VARIABLES OF ELEMENTARY SCHOOL PUPILS IN JAPAN

Chapter V

EFFECTS OF A LABORATORY-CENTERED INQUIRY PROGRAM ON LABORATORY SKILLS, SCIENCE PROCESS SKILLS, AND UNDERSTANDING OF SCIENCE KNOWLEDGE IN MIDDLE GRADES STUDENTS

Development of laboratory skills and science process skills required in the processes and procedures of science and understanding of basic knowledge in science, as products, are considered to be major goals of science instruction at all levels. The laboratory activity has been viewed as an important role in order to attain these goals. However, learning in the laboratory has been and still is a highly controversial issue among science educators (e.g. Hofstein and Lunetta, 1982; Woolnough and Allsop, 1985).

Many of the science curricula developed in the 1960's (e.g. PSSC, CHEM Study, S-APA, SCIS, SCISP, Nuffield) assigned a central role to the laboratory with emphasis on the process of science. Hodson (1988) noted that a significant feature of most of the science curriculum development in the past quarter century was a major shift of emphasis away from the teaching of science as a body of established knowledge toward science as a human activity with increasing emphasis on experience of the processes and procedures of science. Process skill learning has been considered to become an important component of science curricula at all levels by many educators (e.g. Gagne, 1965; Renner, 1966; Herron, 1970; NSTA, 1971; Okey, 1972; Padilla, 1980).

However, Friedler and Tamir (1986) pointed out that, by and large, the outcomes of studying science by laboratory-oriented programs fell short of expectations. Woolnough and Allsop (1985) argue that one reason for the failure of many science courses is the attempt to use the practical work to achieve aims for which it is ill-suited, such as teaching theoretical concepts instead of focusing on the real aims of practical experience. The results of the surveys conducted by the Assessment of Performance Unit (APU) in England also revealed that it is often assumed that either basic practical skills are skills that have been acquired or that they can be acquired in the process of learning about the body of knowledge that is taught (APU, 1984). Fuurthermore, Padilla, Okey, and Garrard (1984) argue that in recent years with the increased popularity of texts and programs that emphasize an even more traditional approach toward science, students have been getting even less experience with the integrated science process skills, and that without a good amount of practice, expectations of skill mastery are probably unreasonable.

Laboratory skills and science process skills cannot be developed just by transmitting the body of knowledge without "minds-on" experience through laboratory-centered inquiry activities. Students need to be involved in scienctific investigations, thereby developing simultaneously those procedural skills in science and gaining a deeper understanding of scicentific concepts, laws, and theories.

The present study was designed in response to the relative scarcity of laboratory-centered inquiry activities in regular science curriculum. The major purpose of this study was to compare the effects of a laboratory-centered inquiry approach to a traditional textbook approach on laboratory skills, science process skills, and understanding of science knowledge in middle grades students. The Foundational Approaches in Science Teaching (FAST) 1 program was integrated into the existing regular middle school curricula at the sixth and seventh grades during the whole school year.

FAST 1, developed by the Curriculum Research and Development Group of the University of Hawaii, is a sequential laboratory- and field-centered inquiry science program. It was designed to provide common foundational experiences in the concepts and methods of science for students in middle school, and its content is selected on the basis of interdisciplinary utility which consists of physical science, ecology, and relational study. Approximately 60% to 80% of class time is spent on student investigation in the laboratory and field, and the remainder of time is spent on analysis of data and discussion (Pottenger and Young, 1983). FAST instructional strategy adopts a sequential inquiry learning cycle derived from the research on learning styles which includes a discrepant event, hands-on investigation, concept development, and application (Young, 1982).

Method and Procedure

Two FAST and two non-FAST teachers in sixth grades classes and two FAST and five non-FAST teachers in seventh grade classes were involved in this investigation. All FAST teachers were certified for teaching FAST 1 through a two-week FAST 1 teacher training workshop and had at least one year of experience to implement the FAST 1 program in their science classes before this investigation. All non-FAST teachers, on the other hand, had neither of these experiences.

A total of 85 sixth grade students consisting of 47 FAST students (two classes) and 38 non-FAST students (two classes) and a total of 141 seventh grade students consisting of 83 FAST students (six classes) and 58 non-FAST students (five classes) were involved in this investigation. The sample group involved was heterogeneous to provide representation across ability levels, socio-economic levels, gender, and race from a relatively rural school district in the eastern part of North Carolina.

During the 1987-88 school year, the FAST 1 program as a laboratory-oriented inquiry approach was integrated into regular science classes in both the sixth and seventh grades (experimental groups). A total of approximately 30% of the FAST 1 content was covered through this integration at each grade level. This total included approximately 40% of physical science -- Unit One: Introduction to the Properties of Matter (problems 1 to 17 at the most) -- and approximately 20% of ecology -- Seed Germination and either Soil and Water or Field Survey. Each activity was introduced in the manner of intended sequence and learning cycle under the instruction of the _FAST 1 Teacher Guide_ (Pottenger, Young, and Kyselka, 1980) and the _FAST Instructional Guide_ (Pottenger and Young, 1983). It was intended that approximately 60% to 80% of class time was spent for laboratory and practical work, and the four-phase learning cycle (a discrepant event, hands-on investigation, concept development, and application) was introduced. Integration was started at the beginning of the school year (September, 1987).

In regular science classes (control groups), it was assumed that traditional teacher-oriented, lecture-demonstration approaches would be predominant, and students would get less hands-on experience of laboratory-oriented inquiry compared to experimental groups. In both experimental and control groups, the same textbook was used at each grade level; i.e., *Holt Science* (Holt, Rinehart, and Winston, 1984) was used in the sixth grade; and *Principles of Science, Book One* (Merrill Publishing Company, 1983) was used in the seventh grade. Both of these books were recommended as state-adopted basic textbooks by the North Carolin Department of Public Instruction. The characteristics of these textbooks are described below:

The *Holt Science* series presents a balance of life, earth, and physical science concepts including interdisciplinary and health-related topics. Science process skills are emphasized through activities and developed throughout the program. Student texts are organized so that each chapter is divided into sections which take two to three days to cover. The section format includes a chapter opener, prestated objectives, "read about" content, activities stressing "hands-on" science experience, summary of main ideas, and application questions (NC Department of Public Instruction, 1985. Excerpt from p.19).

The *Principles of Science, Book One* covers the topics of matter and energy, mechanics, earth science, animals and plants, ecology, and conservation. Each chapter begins with a brief introductory paragraph and goal statement and contains four or five supporting activities that foster the development of problem solving skills. There are review questions at the end of chapters and sections. This book accomodates either a lecture or a "hands-on" approach to instruction (NC Department of Public Instruction, 1985. Excerpt from p.23)

The characteristics of both textbooks described seem to show that activities follow textbook reading as a verification of content taught (deductive approach). The content related to the density concept, which was designed to be taught in the FAST 1 program, was not included in the textbook used in the sixth grade but was included in the textbook used in the seventh grade.

In order to examine the effects of the FAST integration, comparisons were made of the post-test scores at the end of the school year - April, 1988 for the sixth grade and June, 1988 for the seventh grade - between experimental and control groups at each grade level. For the post-tests, three evaluative instruments were used to assess student laboratory skills, integrated science process skills, and understanding of science knowledge. The evaluative instruments were the Performance of Process Skills Test (POPS), FIN Test, and Laboratory Skills Test (LST). In addition to these, the California Achievement Test (CAT) scores (national percentile of the CAT total battery) of individual students were gathered from each teacher in order to establish an equivalency between experimental and control groups.

To evaluate the construct validity of measures, the scores of the three instruments were subject to a factor analysis by grade. The SPSSX-Factor Program, employing the principle components method with varimax rotation to simple structure of all factors having eigen values greater than 1.0, was used. Results of this procedure could provide evidence for convergence and discriminance. Convergent validity between variables is exhibited by high loadings for variables on the same factor, whereas discriminant validity among variables is supported by high loadings coupled with modest loadings on the same factor (modest-high couple). In this study, a high loading is greater or equal to 0.60, a medium loading is greater or equal to 0.40 and less or equal to 0.59, and a low loading is less or equal to 0.39.

The results of the POPS, FIN, and LST Tests for the sixth grade students are shown in Table 45. High loadings on the same factor (factor 1) are observed for the POPS total score with the corresponding LST-Part 2 score. Therefore, substantial evidence for convergent validity between integrated process skills in a general context and individual process skills in a specific context was found. This suggested that the POPS and the LST-Part 2 test items provide a measure on a common underlying structure (dimension) which is defined to be science process skill ability. On the other hand, high loadings on the same factor are not observed for the FIN total score with the corresponding LST-Part 3 score; the FIN total score and LST-Part3 score by themselves exhibit a high factor loading on factor 2 and factor 3, respectively. Therefore, little evidence for convergence between the two knowledge/understanding measures is present. The LST-Part 1 (a laboratory skill measure) does not exhibit a high factor loading on any factors; it exhibits a medium loading on both factor 1 and factor 2. Therefore, little evidence for convergence between laboratory skill and process skill measures, or between laboratory skill and knowledge/understanding measures, is observed.

Modest-high factor loading couples for the LST-Part 2 score (a process skill measure) with the FIN total score and LST-Part 3 score (knowledge/understanding measures), and for the POPS total score (a process skill measure) with the FIN total score, are observed, whereas only half the modest-high couple is seen for the POPS total score with the LST-Part 3 score. The POPS total score exhibits a medium factor loading on factor 3, which exhibits a high loading for the LST-Part 3 score. Thus, substantial evidence for discriminant validity between science process skills and knowledge/understanding measures is found.

The evidence for convergent and discriminant validity provided by the results sixth grade students indicated that the POPS and LST-Part 2 test items provide a measure on a common underlying structure defined as science process skills, which is a differentiated dimension from that of knowledge/understanding measured by the FIN and/or LST-Part 3 test items.

The results of the POPS, FIN, and LST tests in the seventh grade students are shown in Table 46. High loadings on the same factor (factor 2) are observed for the LST-Part 1 score with the LST-Part 3 score. Therefore, substantial evidence for convergent validity between the two measures of laboratory skills related to the density concept and specific knowledge / understanding of the density concept is found. This suggests that the LST-Part 1 and Part 3 test items provide a measure on a common underlying structure (dimension) which is defined to be density concept. On the other hand, high loadings on the same factor are not observed for the FIN total score with the corresponding LST-Part 3 score; the FIN total score exhibits a high loading on factor 3 by itself. Therefore, little evidence for convergence between the two knowledge/understanding measures is present. High loadings on the same factor are not observed for the POPS total score with the corresponding LST-Part 2 score; the LST-Part 2 score exhibits a high loading on factor 1 by itself, while the POPS total score exhibits a medium loading on both factor 1 and factor 3. Therefore, little evidence for convergence between the two process skills measures is observed.

Modest-high factor loading couples for the LST-Part 1 score with the FIN total score were observed. Therefore, substantial evidence was provided for discriminant validity between the two measures of laboratory skills related to the density concept and general knowledge/understanding.

The evidence for convergent and discriminant validity provided by the results in seventh grade students indicates the LST-Part 1 and Part 3 test items provide a measure on a common underlying structure defined as the density concept, which is a differentiated dimension from that of general knowledge /

TABLE 45

ROTATED THREE-FACTOR PATTERN OF POPS, FIN, AND LST SCORES IN SIXTH GRADE PUPILS IN NORTH CAROLINA (N=85)

Variable (Ability*)	Factors		
	1	2	3
POPS (PS)	.71	.09	.48
FIN (KU)	.04	.78	.34
LST-Part 1 (LS)	.55	.41	.32
LST-Part 2 (PS)	.80	.18	.09
LST-Part 3 (KU)	.10	.55	.76
Eigen Value	1.45	1.13	1.04
Percent of Variance Accounted For	29.03	22.57	20.76

*Ability Tested:

PS: Integrated Science Process Skills

KU: Knowledge and Understanding in Science

LS: Practical Laboratory Skills

TABLE 46

ROTATED THREE-FACTOR PATTERN OF POPS, FIN, AND LST SCORES IN SEVENTH GRADE PUPILS IN NORTH CAROLINA (N=141)

Variable (Ability*)	Factors		
	1	2	3
POPS (PS)	.54	.04	.52
FIN (KU)	.42	.34	.62
LST-Part 1 (LS)	.51	.74	.05
LST-Part 2 (PS)	.78	.11	.37
LST-Part 3 (KU)	.48	.63	.49
Eigen Value	1.55	1.08	1.03
Percent of Variance Accounted For	31.09	21.65	20.59

*Ability Tested:

PS: Integrated Science Process Skills

KU: Knowledge and Understanding in Science

LS: Practical Laboratory Skills

understanding mesured by the FIN test items.

Inspection of both sixth and seventh grade data shown in Table 45 and Table 46 reveals that, in common, the tests used in this investigation measure three distinctive underlying dimensions: science process skills (the POPS and/or LST-Part 2 tests), specific knowledge/understanding related to the density concepts (the LST-Part 3), and general knowledge/understanding (the FIN test). The LST-Part 1, designed to measure laboratory skills related to density concepts, tends to be associated with the dimensions of science process skills and/or specific knowledge/understanding related to the density concepts.

Results of the Study

To examine the main effects of the FAST treatment by each grade, the Multivariate Analysis of Covariance (MANCOVA) was conducted by using the SPSSX MANOVA subcommand. The overall omnibus F-value, which represents the main effect of FAST treatment on three dependent variables (the POPS, FIN, and LST total scores) with the CAT total score as a covariate, showed significance using Wilk's criterion in the sixth grade group [$F(3,80) = 6.80$, $P < 0.001$] and in the seventh grade [$F(3,136) = 13.30$, $P < 0.001$]. In addition, as the LST test was divided divided into three subtests, a significant main effect of FAST treatment was also found on five dependent variables (the POPS, FIN, LST-Part 1, LST-Part 2, and LST-Part 3 tests) with covariate CAT, both in the sixth grade group [$F(5,78) = 5.53$, $P < 0.001$] and in the seventh grade group [$F(5,134) = 11.14$, P < 0.001]. These results indicate the students laboratory skills, integrated science process skills, and understanding of science knowledge as a whole ability seem to be affected by the FAST 1 instruction utilized at each grade.

To examine the effects of the FAST treatment on each individual dependent variable by each grade, the univariate one-way Analysis of Covariance (ANCOVA) was conducted by using SPSSX MANOVA subcommand. The adjusted mean scores of each test by CAT score and the results of ANCOVA with covariate CAT are shown in Table . Significant differences on the LST total scores were formed between the FAST and non-FAST groups for both the six graders [F(1,82) = 19.45, P < 0.001] and the seventh graders [F(1,138) = 28.74, P < 0.001]. However, no significant differences on the POPS and FIN total scores were found between the two treatments with either grade level.

Closer analysis of the LST test where significant effects of the treatments were found at both grade levels was possible through examining abilities tested and the degree to which the FAST instruction influenced them. To accomplish this, the LST test was divided into three subtest: a subtest of laboratoey skills related to the density concept (Part 1); subset of specific science process skills, i.e., graphing and interpreting data (Part 2); and subtest of specific knowledge/understanding of the density concept (Part 3). The subtest scores were analyzed using the univariate one-way Analysis of Covariance (ANCOVA) covarying on the CAT total score. The adjusted mean scores of the subtests by the CAT scores and the results of ANCOVA are contained in Table .

Significant differences on the laboratory skills subtest (LST-Part 1) were found between the FAST and non-FAST groups for both the sixth graders [F(1,82) = 19.05, P < 0.001] and the seventh graders [F(1,138) = 43.29, P < 0.001]. Significant differences on the process skills subtest (LST-Part 2) were also found between the two treatments for both sixth graders [F(1,82)= 8.44, P = 0.005] and the seventh graders [F(1,138) = 7.40, P = 0.007]. However, no significant differences due to treatment were obtained on the knowledge/understanding subtest for the seventh grade students [F(1,138) = 1.89, P = 0.171], whereas significant differences were found for the sixth grade students [F(1,82) = 4.58, P = 0.035].

These results showed that the FAST 1 instruction integrated into regular science classes seemed to significantly affect, especially on laboratory skills (the LST-Part 1) and specific process skills such as graphing and interpreting data (the LST-Part 2) from students at both grade levels. However, the FAST integration did not seem to significantly affect the integrated science process skills as a whole (the POPS total) and knowledge/understanding in general contexts (the FIN total). Yet, support was obvious for the main effects of the FAST instruction on laboratory skills, science process skills, and understanding of science knowledge as a whole for students in both the sixth and seventh grades.

TABLE 47

ADJUSTED MEAN SCORES OF THE POST-TEST BY THE CAT SCORES AND RESULTS OF ANCOVA WITH COVARIATE CAT BY GRADE IN NORTH CAROLINA

Test	Maximum Score	6th Grade			7th Grade		
		Treatment		F-Value	Treatment		F-Value
		FAST 1 (N=47)	Non-FAST (N=38)	(df= 1,82)	FAST 1 (N=83)	Non-FAST (N=58)	(df=1,138)
Dependent Variables:							
POPS Total	21	8.88	8.11	1.64 (NS)	9.22	10.32	3.69 (NS)
FIN Total	6	1.19	0.99	1.24 (NS)	0.95	1.21	2.83 (NS)
LST Total	16	2.51	0.82	19.45***	3.79	1.83	28.74***
LST-Part 1	6	0.71	0.12	19.05***	1.49	0.30	43.29***
LST-Part 2	6	1.37	0.48	8.44**	1.86	1.21	7.40**
LST-Part 3	4	0.43	0.23	4.58*	0.44	0.32	1.89 (NS)
Covariate:							
CAT Total (Observed Mean)	100	50.28	45.92	-----	50.23	51.91	-----

*** p<0.001

** p<0.01

* p<0.05

NS: not significant

Discussion of the Results

To examine the effects of laboratory-centered inquiry instruction compared to traditional textbook-centered instruction on the student laboratory skills, science process skills, and understanding of science knowledge, the Foundational Approaches in Science Teaching 1 (FAST 1) was integrated into the existing regular science curriculum for the whole school year in the experimental group, while in the control group FAST 1 was not used and it was assumed that traditional teacher-centered, lecture-demonstrated approaches would be predominant as compared to the experimental group. In both groups, the same textbook was used by the different teachers. All FAST teachers were certified through a two-week workshop and had at least one year's experience to implement the FAST 1 program in their classes before this investigation, while non-FAST teachers had neither of these. A total of approximately 30% of the FAST 1 content was covered through the whole year integration. Each activity was introduced in a manner of intended sequence and learning cycle under the instruction of the teacher guide. The students in the sixth and seventh grades involved in this investigation were heterogeneous to provide representation across ability levels, socio-economic levels, gender, and race. In terms of the California Achievement Test (CAT) scores of individual students, both FAST and non-FAST groups were considered to be equivalent at the sixth grade ($t = 0.882$, $df = 83$, $p > 0.05$) and the seventh grade ($t = 0.371$, $df = 139$, $p > 0.05$).

Yet it might still need to be considered that there are unknown factors influencing the student outcomes measured by the post-tests after the instruction was completed. Student characteristics, teacher characteristics, instruction, materials, educational environment, and interactions among these factors all have a bearing on the learning outcomes of students.

Through a review of related research studies, it was hypothesized that the intervention of a laboratory-centered inquiry program (FAST 1) into a textbook-oriented regular curriculum could result in increased student abilities dealing with laboratory skills, science process skills, and understanding of science knowledge. To test this hypothesis, the post-tests including three types of measures which were a measure of manipulative laboratory skills (the LST-Part 1), two measures of science process skills (the LST-Part 2 and the POPS), and two measures of knowledge/understanding (the LST-Part 3 and the FIN) were administered to both FAST and non-FAST students at the end of the school year after the treatments were completed.

Construct validity for these three types of measures was examined by a factor analysis employing the principal component method with varimax rotation. It was indicated that the LST-Part2 and POPS test items could provide a measure on a common underlying structure defined as science process skills ability, and the LST-Part 3 could provide a measure of specific knowledge or unnderstanding of the density concept, which were differentiated from the dimension of general knowledge or understanding measured by the FIN test. Laboratory skills measured by the LST-Part 1 tend to be associated with the dimensions of science process skills and/or specific knowledge or understanding of the density concept.

The effects of the FAST treatment on each individual ability were examined by grade by conducting the univariate one-way Analysis of Covariance (ANCOVA) with the CAT total score as covariate. The main effects of the FAST treatment on total ability as a whole were also examined by grade by conducting the Multivariate Analysis of Covariance (MANCOVA) covarying on the CAT total score.

Laboratory skills as one of the students learning outcomes were measured by the LST-Part 1. This subtest of the LST (six items) was designed to assess the manipulative basic skills (four items) dealing with measuring height, area, mass, and volume of liquid displaced and the abilities (two items) dealing with calculating and comparing the density of liquids, which requires the knowledge/understanding of the density concept in the process. All of these abilities were intended to be taught in the context within which FAST instruction was presented. Therefore, the LST-Part 1 is considered to be a measure of specific transfer of manipulative laboratory skills into a similar situation for the FAST students. The scores of the LST-Part 1 might be differentiated because of two reasons: First, if the students do not get enough hands-on experience to deal with manipulative basic process skills, then inevitably the scores would be differentiated in favor of the FAST treatment. The content related to the density concept was not included in the textbook used in the sixth grade but was included in the textbook used in the seventh grade.

The scores of the LST-Part 1 (six items) were compared for each grade. The results showed that significant laboratory skills differences were found in favor of the FAST treatment for both sixth and seventh grade students. These results implied that non-FAST students might get less hands-on experience to deal with manipulative basic process skills and/or they might get less knowledge and understanding of the density concept as a prerequisite as compared to the FAST students. Manipulative basic process skills are considered not to depend on the context, and the evidence was provided, especially by the seventh grade results, which showed that even though the density concept was included in both FAST and non-FAST groups, significant differences were still found. Therefore, it could be suggested that the intervention of the FAST program into a regular class as a laboratory-centered inquiry approach seems to result in increasd student laboratory skills. Yet, as indicated by the inspection of construct validity of measures which showed that laboratory skills measured by the LST-Part 1 tend to be associated with the dimensions of science process skills and/or specific knowledge/understanding of the density concepts, a closer analysis of the LST-Part 1 test items might still be necessary.

Science process skills as one of the student learning outcomes were measured by the POPS and LST-Part 2. The POPS (21 items) was designed to assess six integrated science process skills dealing with identifying experimental questions, identifying variables, formulating hypotheses, designing investigations, graphing data, and interpreting data. This test is a non-curriculum specific measure and contains content-free test items which are referenced to a general context. Therefore, the POPS is considered to be a measure of general transfer of science process skills beyond the specific context. On the other hand, the LST-Part 2 (six items) was designed to assess specific individual process skills dealing with graphing and interpreting data in a familiar context related to mass and volume, within which the FAST instruction was presented. These process skills such as linear graph construction, direct reading of graph, interpolate and extrapolate from graph, and calculate density using graphed data were intended to be taught directly through the FAST instruction. Therefore, the LST-Part 2 is considered to be a measure of specific transfer of individual process skills into a familiar context for the FAST students.

Yet, the inspection of construct validity of measures showed that the LST-Part 2 and POPS test items could provide a measure on a common underlying structure defined as science process skills ability, and this dimension was differentiated from those of general knowledge/understanding and specific knowledge / understanding of the density concept. Through a review of related research studies, support is clear that science process skills can be taught and learned if the students have an appropriate amount of experience exposed to the situation dealing with this ability. Therefore, in general, if the students do not get enough laboratory-oriented inquiry experience to deal with science process skills, the process skills scores would be differentiated in favor of the FAST students.

Each of the POPS (21 items) and LST-Part 2 (six items) scores were compared between the treatments by grade. The results showed that significant differences on the LST-Part 2 were found in favor of the FAST treatment for both sixth and seventh grade students. However, no significant differences were found on the POPS total scores with either grade level. These results imply that the FAST students might transfer specific individual process skills into a familiar context but not total integrated process skills into a general context and that non-FAST students might get less experience to deal with specific individual process skills. The differentiation of the LST-Part 2 scores and non-differentiation of the POPS total scores also imply that specific individual process skills might depend on the context familiarity within which instruction was presented. It could be suggested from these results that the intervention of the FAST program into a regular class as a laboratory-centered inquiry approach seems to result in increased specific individual process skills, i.e., graphing and interpreting data. Little evidence for the acquisition of total integrated science process skills ability in a general context is present. Closer analysis of the process skills ability might be necessary through examining specific skills and the degree to which the instruction influenced them by dividing the POPS test into its subtests.

Understanding science knowledge (science achievement), as one of the student learning outcomes, was measured by the FIN and LST-Part 3. The FIN (six items) was designed to assess knowledge and understanding about conservation of weight, direction of gravitational force, and water pressure as force in a general and outside context from the FAST instruction (three items) and knowledge and understanding about existence of buoyancy, subsurface floating, and density of object in the extended context from the FAST instruction (general transfer and application) which are relatively in a general context (three items). The LST-Part 3 (four items) was designed to assess knowledge and understanding about floating/sinking and density in a specific context relatively related to the FAST instruction (specific transfer). The inspection of construct validity showed that the FIN could measure on a general knowledge/understanding dimension, which is differentiated from that of specific knowledge/understanding of the density concept measured by the LST-Part 3. The acquisition of knowledge and understanding can be directly influenced by the content instruction plus process instruction associated with the content. Through a review of related research studies, support is clear that laboratory-oriented inquiry approaches can enhance student achievement in science. Thus, if the students get less or none of the content instruction, it would result in the differentiated scores on these tests. Further, if the student got less or none of the process instruction associated with the content, the content achievement scores would be differentiated. The content related to the density concept was not in the sixth grade textbook but in the seventh grade textbook.

Each of the FIN (six items) and the LST-Part 3 (four items) scores were compared between two treatments by grade. The results showed that significant differences on the LST-Part 3 were found in favor of the FAST students in the sixth grade. This result implied that the FAST-students might transfer the specific knowledge/understanding which was directly taught through the FAST instruction into a related context, whereas the non-FAST students might not get the specific content instruction, thus the scores were differentiated. However, the results showed that no significant differences were found on the LST-Part 3 in the seventh grade. Further, no significant differences were found on the FIN total scores with either grade level. Therefore, little evidence for the acquisition of knowledge and understanding in science is present. Additional information about what and how the content was taught in the science classes might still be necessary for further analysis.

Total ability in science laboratory skills, science process skills, and understanding of science knowledge as a whole was measured by all tests combined. Through a review of related research studies, it was assumed that laboratory skills and science process skills could not be developed just by transmitting the body of knowledge without hands-on experience through the laboratory-centerd inquiry activities and that the students would need to be involved in scientific investigation thereby developing simultaneously these procedural skills in science and gaining deeper understanding of science knowledge. Thus, it was hypothesized that the intervention of a laboratory-centered inquiry program (FAST 1) into a textbook-oriented regular curriculum could result in increased student total ability in science. The scores of the combination of all tests were compared between two treatments by grade. The results obviously showed that significant main effects of the FAST treatment were found on the total ability in science for both sixth and seventh grade students. Therefore, the hypothesis was supported by this evidence.

Concluding Remarks

The present study was designed in response to the relative scarcity of laboratory-centered inquiry activities in regular science curricula. The major finding from this study is that the integration of the FAST program into a regular science curriculum as a laboratory-oriented inquiry approach seems to result in increased student total ability in science, i.e., laboratory skills, science process skills, and understanding of science knowledge as a whole, over a long period of time. In a more general statement, it appears that an integration of science content and process instruction through laboratory-oriented inquiry activities seems to result in great benefit to students. Hopefully, this study could provide an additional support for positive encouragement of science curriculum and instruction with emphasis on laboratory-oriented inquiry.

Chapter VI

THE IMPLICATION OF SCIENCE TEACHING CONTENT APPROPRIATENESS TOWARDS CURRICULAR REVISION IN JAPAN

The Ministry of Education, Science and Culture of Japan is the central body that determines the curricular standard that are being implemented by schools throughout the nation. It determines the objectives and activities that are to be used for kindergarten, and the subject areas to be offered in the elementary, lower and upper secondary schools, as well as the required number of school hours for each subject in all school levels. It certainly determines the objectives and content of each subject area and therefore direct all of these to be incorporated in the "Course of Study" for all the school levels. Every school then organizes its own school curriculum in line with the "Course of Study" which is designed for use nationwide, and also in due consideration of the real condition of the school and its location, as well as the characteristics of the learners enrolled and the stages of their cognitive, affective, and physical development.

In line with the value of knowing the cognitive, affective, and physical development of the learners, various data were gathered by the researchers through the use of several evaluative instruments. In this study, the researchers have used achievement tests in science using grade six elementary school pupils from various parts of the country in order to determine the appropriateness of the current curriculum in science. The recommendations for curricular change concerning the science teaching content were based on their appropriateness as depicted on the achievement of the pupils as well as on the recommendations made by the different teachers. The recommendations made would be used in the revision of the standard of the course of study in science.

Sample Items of the Achievement Test Used

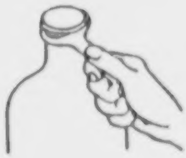
The "Course of Study" in science for the elementary schools in Japan was the basis in determining the contents of the questions utilized in the achievement test. The achievement test questions are directly in consonance with the overall objective of science teaching at the elementary school level which is to develop the ability in and the attitude towards making inquiries about nature through observation and experiments as well as to enhance their understanding of natural things and phenomena, thereby nurturing a rich sensitivity to love nature.

There are eight sample items presented in this section covering topics such as the interrelationships among concepts in lever specifically the fulcrum, the effort, and the resistance. Tools commonly used in daily life were used as illustrative materials to bring closer to the pupils the idea that levers are real objects which they use everyday in their toys, or often found in school and in their homes. The pupils' understanding of the concept of balance and their ability to apply the concept of lever in practical situations were also assessed.

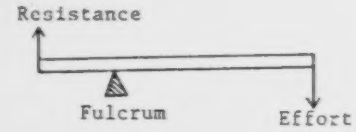
SAMPLE TEST ITEMS

Achievement Test Questions About Lever for Grade Six Pupils

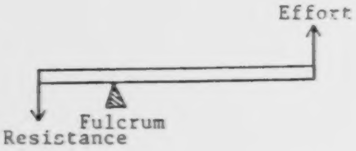
A. The picture on the right shows a bottle being opened using an opener. Take a look at the four diagrams shown below. You can see the three points of forces namely: Fulcrum, Effort, and Resistance. Write the number of the condition that could illustrate the process of opening a bottle. Write your answer in the box provided for it.



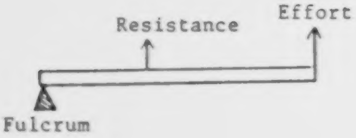
1)


Resistance
Fulcrum
Effort

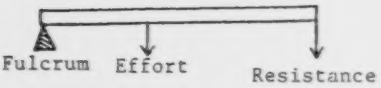
2)


Effort
Fulcrum
Resistance

3)


Resistance
Effort
Fulcrum

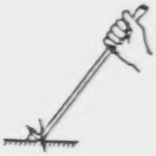
4)


Fulcrum
Effort
Resistance

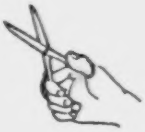
☐

B. You can see below the different tools people commonly use. There are three tools that have similar location of fulcrum. Indicate the number of the tool that has a fulcrum different from the other three tools in the box provided for.

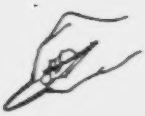
I. 1)



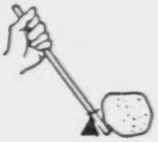
2)



3)

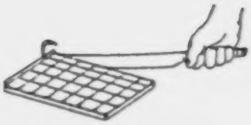


4)

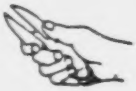


☐

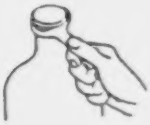
II. 1)



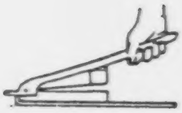
2)



3)

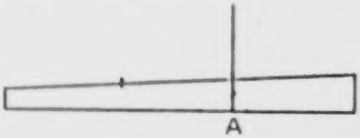


4)



☐

C. The following diagram shows a bar on its balanced state.

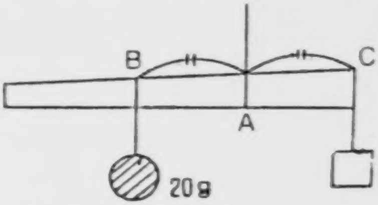


I. If you cut the bar into two at point A, what do you think will happen? Write your answer in the box provided for.

1) The left bar would be heavier.
2) The right bar would be heavier.
3) Both of the bars would have similar weight.
4) The left bar would be twice as heavy as the right bar.

☐

II. If you put the weight at point C, how many grams would you be adding in order to maintain the balance condition of the bar?

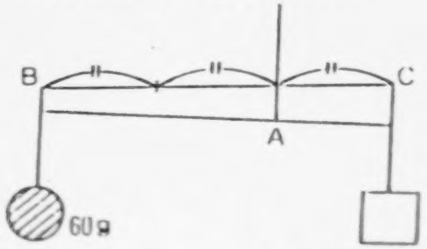


Select your answer from choices 1 to 4 and put it in the box provided for.

1) 1 g
2) 10 g
3) 20 g
4) 40 g

☐

III. The length of AB is two times the length of AC. When you want to maintain the balance condition of the two sides, how many grams should you place at C?

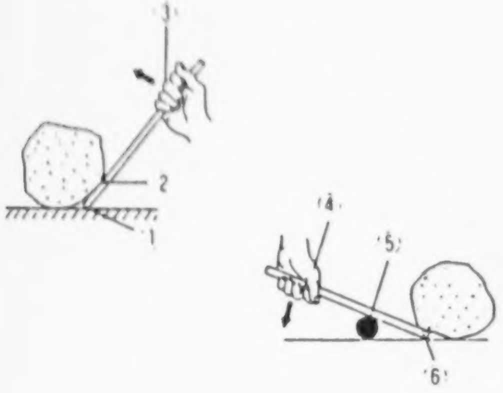


Select your answer from choices 1 to 4 and then put your choice in the box provided for.

1) 60 g
2) 30 g
3) 15 g
4) 120 g

☐

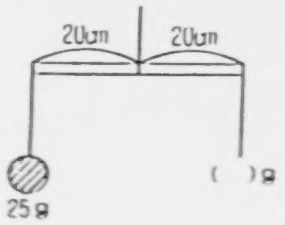
D. Look at the pictures below. Indicate the number corresponding to the resistance in the boxes provided for.



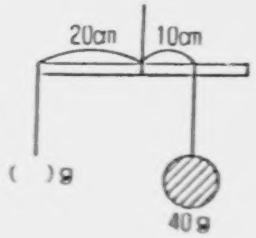
☐ and ☐

E. You wanted to maintain the balance condition of the following bars, numbered 1 to 6. Write down the weight that could maintain their balance in the boxes provided for each item. (Disregard the weight of the bars.)

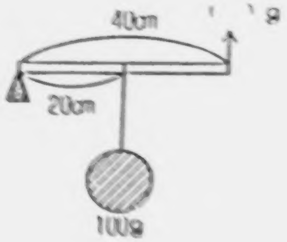
a)


20cm
20cm
25g
( )g

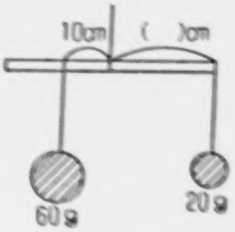
b)


20cm
10cm
( )g
40g

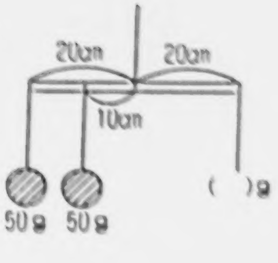
c)


40cm
( )g
20cm
100g

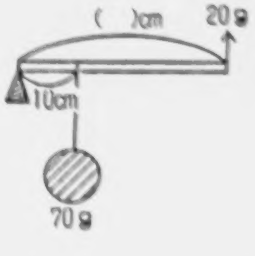
d)


10cm
( )cm
60g
20g

e)


20cm
20cm
10cm
50g
50g
( )g

f)

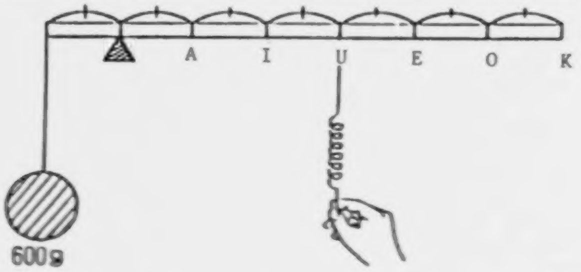

( )cm
20g
10cm
70g

1) 20
2) 60
3) 75
4) 50
5) 45
6) 5
7) 25
8) 35
9) 15
10) 30

a) ☐ g b) ☐ g c) ☐ g

d) ☐ cm e) ☐ g f) ☐ cm

F. The picture below shows a bar with a weight attached to it. (Ignore the weight of the bar itself.) The weight required can be measured using the elasticity of the spring.



I. The table below shows the data taken from the observations made on the experiment. Fill in the boxes provided for in A and B by selecting your answer from the choices numbered 1 to 8.

Attachment Point	A	I	U	E	O	K
Elongation Length		30 cm		15 cm	12 cm	10 cm

1) 10   2) 20   3) 30   4) 40

5) 50   6) 60   7) 70   8) 80

II. Using the same spring, what would be the length of elasticity if the weight placed would be 400 grams. Write your answer in the box provided for.

1) 10 cm
2) 20 cm
3) 30 cm
4) 40 cm

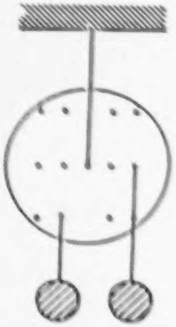
☐ cm   ☐ cm

III. When the spring elasticity is 18 cm., what part of the lever is the location of the spring? Write the number of your answer in the box provided for.

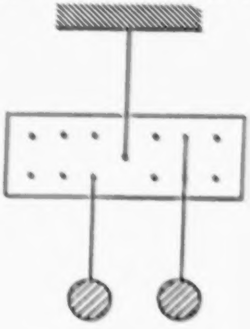
1) Between A and I
2) Between I and U
3) Between U and E
4) Between E and O

6. From the pictures below, select the balance that could make a horizontal position possible. Write your answer in the box provided for. (The weights of the balls are the same)

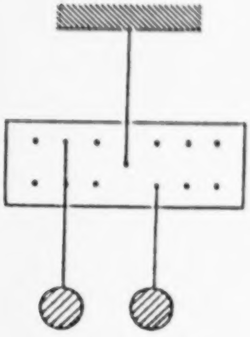
1)



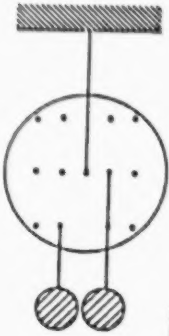
2)



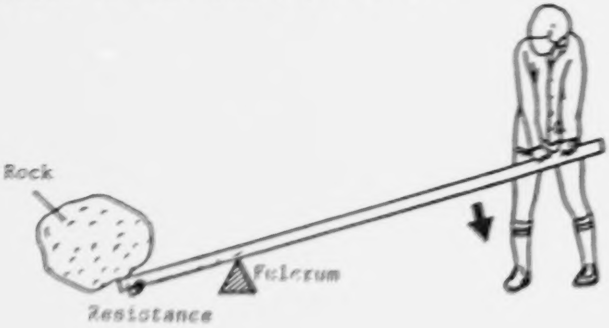
3)



4)



11. Taro would like to move a big stone by using a lever. Before he moved the stone, he made a hypothesis. What do you think was his hypothesis? Select from the four choices given below. Write your choice in the box provided for.



1) If he is heavy enough, then he only needed a small force.
2) When the fulcrum used is strong, he would only exert a small force.
3) The farther the distance between the fulcrum and the effort, the lesser force would be required.
4) The farther the distance between the fulcrum and the resistance, the lesser force would be required.

☐

I. Would you try to recall your experiences related to the aforementioned problems. Write an (X) in the parenthesis beside each number if you have experienced doing the corresponding activity.

1) ( ) Did you ever perform an experiment on these topics by yourself?

2) ( ) Did you ever read with understanding textbooks related to this unit?

3) ( ) Did you ever read with understanding books and other reference materials related to this unit?

4) ( ) Did you ever perform exercises on this unit by using problem solving and calculating techniques?

5) ( ) Did you ever study this unit with interest?

6) ( ) Did you ever write your own ideas and logical thoughts in your notebook when you studied this unit?

7) ( ) Did you ever experience discussing with your classmates about this unit?

8) ( ) Did you ever fail to study about this unit at school and at home?

9) ( ) Did you ever experience studying about this unit outside the school and the home?

10) ( ) Did you ever think this unit is important for your life in the future?

Recommendations Made on the Contents of Science Teaching for Grade Six Pupils at the Elementary Schools

This section of the study presented the contents of the elementary school science for grade 6 pupils in Japan. The contents were categorized into "Living Things and Their Environment", "Matter and Energy", and "The Earth and the Universe". The different data presented in this section further described the specific teaching contents, achievement test results, analysis of teachers responses on a questionnaire, and the recommendations for curriculum revision made by the teachers.

A. Living Things and Their Environment

The main objective of teaching science under the "Living Things and Their Environment" section is to make pupils, while examining the growth and reproduction of plants and the human body, understand that living things grow and are reproduced under the mutual influence from the other living things and the structure and functions of the human body, and develop an interest in interrelationship between living things and their environment, and foster an attitude of respecting life.

The first content described under this same section is as follows:

> To make pupils understand that plants grow by influencing each other while examining the places where plants grow thickly.

a. If some of the thickly-growing plants are removed, the growth of plants changges because of the change in the amount of sunlight, etc.

b. In the place where plants grow thickly, plants in the middle of and on the fringe of the place are different in their growth because of the diference in exposure to the sun or in temperature.

The achievement test result in this content suggested that 78.4 % of all the grade six elementary school pupils were able to answer the questions about it correctly. With this percentage, the teachers possess the idea that the concepts on the growth of plants is easily assimilated by the grades six pupils. It is easy for the learners to find out the differences on the growth of plants under various environmental conditions.It is easy for them to observe the fact that densely growing plants do not grow as well as those that are located in sparsely planted area because of the small amount of sunlight that penetrate on them. So the pupils can easily understand the fact that plant growth is affected by various environmental conditions.

It has therefore been recommended by the teachers that their teaching content should be transferred to the lower grades because it is too easy for grade six pupils at the elementary level.

The second content assessed through the achievement test is on the relationship between pollination and fructification. The content is described as follows:

To make pupils, by examining the process of forming fruits from flowers, understand the relationship between pollination and fructification.

a. Pollen attaches itself to the stigma, and plants produce seeds.

b. Insects and wind participate in pollination.

The result of the achievement test presented that 77.8 % of the grade six elementary school pupils were able to answer correctly the questions related to polination and fructification. The teachers stated that it is easy for the learners to observe the fact that a pollen grain attaches itself to the stigma during the process of fruit formation and that eventually the production of seeds would occur. Although the experiments available for pupils allow the acquisition of understanding about the relationship between pollination and fructification, it can be stated that the science teachers in Japan commonly guide learners on the proper ways of conducting experiments with special emphasis on gathering data from observation exercises related to these topics. A lot of textbooks are also available containing the pollination and fructification concepts. The beautifully drawn pictures in these books depict insects and wind movement as they affect pollination process.

These materials were thought of by the teachers to be the cause of the good results in the achievement test. It has been recommended that this content should be transferred to grade five. This content should be combined with the lesson on hatching of fish eggs presently included in the grade five curriculum.

This combination of lessons on plant pollination and fish eggs fertilization could strengthen the understanding about the process utilized in observing behavior of male and female fishes. This could be possible because the concepts of plant and animal reproduction are very similar. Both of these lessons should therefore become a part of the curriculum for the elementary school pupils.

The third content under the "Living Things and Their Environment" dealt on the structure and fuction of the human body. The subject matter incorporated in this content were described as follows:

To have pupils, by examining respiratory and digestive functions of the human body, understand outlines of the structure and function of the human body.

a. The human body is supported by bones, and man can move his body using muscles around the bones.
b. Pulse and breathing rates change when one exercises.
c. Man takes oxygen into his lungs and exhales carbon dioxide.
d. Food is ground by teeth, changed by saliva, carried through the digestive tube, and absobed as nutriment and discharged out of the body.
e. Blood circulates within the body by the function of the heart, and carries nutriment, oxygen, carbon dioxide, and others.

It has been found that 62.4 % of the pupils who took the achievement test were able to get the correct answer for the item made for this content. It has been stated by teachers involved in this study that they often asked their pupils to read textbooks in order to understand the respiratory and digestive functions of the human body. They seldom used experimentation process. Instead, they commonly used the lecture method in dealing with this content. Through X-Ray and skeleton models, the understanding of the pupils about the human body with special attention on the muscles and bones has been enhanced by the teachers.

It has been recommended that teachers should include other animals as objects of study when the topics are on the outlines of the structure and functions of the human body. The content on bones and muscles should be integrated with the topics related to the structure and functions of plants and animals which will be taught at the grade three level of the elementary schools. It was recommended that the content dealing on the fact that human beings inhale oxygen into their lungs and then carbon dioxide is released during the process of exhalation could be taught along with the study of animal respiration.

B. Matter and Energy

It is the objective of the "Matter and Energy" section to enable pupils, while examining the properties of water solution, how substances are warmed or burned, the function of a lever, the function of an electromagnet, etc., understand the properties of substances and regularity in their changes, and foster an attitude to investigate actively the unknown by applying such knowledge to the natural phenomena.

The first content that was used from the "Matter and Energy" section was on the examination of dissolved substances in water. It is presented as follows:

> To make pupils understand the properties of the water solution while examining dissolved substances in water.
>
> a. Some solutions contain dissolved gases.
>
> b. There are three types of water solution - acid, alkali and neutral.
>
> c. Some solutions dissolve metal.

The achievement test result presented that 66.2 % of the pupils were able to answer correctly the questions related to the dissolved substances in water. It was stated by the teachers that the students are usually interested in observing the properties of a water solution. The children are described to be so interested on the phenomenon that some solutions are capable of dissolving metals. By nature, they say that children are interested in chemical changes.

It was recommended that another item on chemical reaction and changes should be added to their content. The phenomenon of the neutralization process which commonly occur when acids and bases are mixed together. This content should therefore be added to the above-mentioned content because children are so interested in chemical reactions.

The second content under the "Matter and Energy" section is on the phenomenon on burning of substances. The content is shown as follows:

To make pupils, by examining the state of a substance burnt with a flame, understand that a flame is produced when a gas is burnt.

a. A flame has several parts in which there are differences in color, brightness and temperature.

b. A flame is produced when a gas is burnt.

c. If a piece of wood is strongly heated without ventilation, combustible gas, etc., are produced and charcoal is left as residue.

The achievement test results suggest that 62.9 % of the pupils were able to answer correctly the problems on the state of substances when burned. The study on flame is considered to be easy and as well as the experiments on examining the state of substances burned without air ventilation.

It was recommended that in order to enhance the understanding of the pupils about the function of air in combustion, they should be allowed to examine the changes in the air when the substances are burnt. It must also be emphasized that children should be able to know the value of air in combustion of substances. Oxygen is the gas inhaled by man and animals and that carbon dioxide is in turn exhaled during respiration process. Carbon dioxide is also produced when plant substances are burned. Oxygen causes the rapid combustion of burning materials. This content on combustion should therefore be added to the aforementioned content. In addition, it should be considered that when a piece of iron is burned, it may lose its characteristics. This should be added to this content too. The pupils should also be allowed to perform experiments in which they could observe the actual process of combustion.

The third content under the "Matter and Energy" section included topics on changes of substances when heated. The content is described in the following terms, to wit:

> To have pupils understand how objects are heated while examining changes of substances when heated.
>
> a. When metal is heated, the heat is conducted from the heated part to the other parts.
>
> b. There are conductive and less conductive substances.
>
> c. The transfer of heat in water and air takes place by currents in the fluids which are induced because heated fluid becomes less dense than cold fluid, then rises in temperature.
>
> d. Substances, though their volume changes due to the temperature, do not change in their total weight.

It was reported that 71.1 % of the pupils who took the test were able to answer correctly the problems on the changes of substances when heated. It was stated by the teachers that observing the transfer of heat from the heated part of the metal towards its other parts can be considered as easy for the grade six pupils. The transfer of heat in heated water and air takes place in the form of current as is common to all fluids. However, it would be very difficult for the children to understand the fact that heated water is less dense than cold water.

It was recommended that this content can be transferred to the lower grades, specifically grade four of the elementary school level. It should be transferred to this level because the grade four pupils are studying topics on the contents of heat in which they deal with the volume and the effect of temperature. They also learn about the fact that water can be changed from one state to another due to the effect of temperature changes. So the study of heated metal and transfer of heat should be emphasized at the lower grade levels. The difficult topics related to the density changes of water should be transferred to the higher school levels. The content being studied by the grade six pupils about the volume of metals should be transferred to grade four level so that it could be studied along with the volume of water and changes in air temperature.

The fourth content under "Matter and Energy" dealt on topics about lever. It can be described as in the following:

> To make pupils,by using a lever and examining the points where the force is applied and, understand the principles of a lever and some tools to which the principles of a lever are applied.
>
> a. It is possible to move heavy objects with small force by making use of a lever.
>
> b. The magnitude of force can be measured by the weight of an object or the stretch of a spring.
>
> c. Even though the position of a weight is changed on a

lever, the weight itself does not change at all. However, the function of tilting a lever changes.

d. A lever is balanced when the function of tilting a lever on both sides is equal.

e. Some tools, whose purpose is to change the direction of force or the magnitude of force, use the principles of a lever.

It was reported that 62.4 % of the pupils who took the test were able to answer correctly the problems on the lever. This percentage suggests that the item is just fitted for the grade six pupils. The pupils were also found to be so interested with the lever phenomenon.

At the grade five level, the science and mathematics subject areas emphasize the importance of quantitative calculations. The teachers should therefore develop more contents that could continue nurturing the quantitative thinking skills of the pupils at the grade five level. To further strengthen the quantitative skills of the pupils, it could be possible to transfer the content on lever to the grade five level.

The fifth content under the section "Matter and Energy" stressed topics on electromagnets. A sample activity is the examination of magnetic force and magnetic poles. This content has been described as in the following:

> To have pupils, by making an electromagnet and examining magnetic force and magnetic poles, understand the function of the electromagnet.

a. A coil charged with electricity magnetizes an iron core.

b. When the direction of the current is changed, the magnetic poles are also changed.

c. The magnitude of an electromagnet depends upon the magnitude of the current and the number of coils in the winding, etc..

d. The magnitude of current can be measured by an ammeter.

The number of pupils who were able to correctly answer the problems on electromagnet consisted of 75.7 % of those who took the test. The percentage of students suggest conditions in which the item is easy for the pupils. They seem to have shown enjoyment dealing with the task on electromagnet.

The recommendations made consisted of showing actual application of electromagnetism concepts to children at the elementary school level. The pupils should therefore be allowed to do activities involving manipulative skills some samples of which are making simple tools and gadgets wherein the principle of electromagnetism is applied. The pupils should be allowed by their teachers to construct toys, big and small, simple motors, electric bells and similar simple machines as part of their practical experiences.

C. The Earth and the Universe

This section on "The Earth and the Universe" has as its primary objective to make pupils, by examining a state of strata, the movement of the sun, the change of temperature on the surface of the ground, understand the function of water and sunlight which influences the ground, and foster as attitude to observe natural phenomena in terms of the lapse of time and the expanse of space.

The first content under "The Earth and the Universe" dealt on changes of atmospheric temperature in different seasons. It is described as in the following:

> To make pupils understand the reasons for the changes of atmospheric temperature in different seasons, while examining the altitude of the sun and the changes of atmospheric temperature in different seasons.
>
> a. Atmospheric temperature depends on the temperature of the ground heated by the sun, and these two temperatures undergo similar changes.
>
> b. The changes of atmospheric temperature in the seasons depend on the altitude of the sun and on the length of daytime.

It was reported that 62.5 % of the pupils who took the test the test were able to answer correctly the portions on changes of the atmospheric temperature in different seasons. The teachers involved in the study however described that the children encountered difficulty in understanding the seasonal changes. Many of the pupils failed to recognize the fact that seasonal changes and length of day and night time are affected by the altitude of the sun. The pupils seem to dislike doing observation activities about seasonal changes because of the time required to complete them. The task of recording seasonal changes seem to be not so attractive to them.

It was therefore recommended that this content be transferred for the learners at the lower secondary school level. The students at this level have longer attention span which is a prerequisite for this kind of observation activity.

The second content included in "The Earth and the Universe" section dealt on strata formations as a result of the force exerted by running water and other materials towards the ground. The areas included in this content are as follows:

> To have pupils understand that some of strata formation are the results of the function of running water, etc., while examining the way of forming the strata of the earth and the composition of the strata.
>
> a. Some parts of the land are stratified.
>
> b. Strata are characterized by their state of layers, the thickness of the stratum, and the substances contained in the stratum.
>
> c. Strata have wide extent of the layers.
>
> d. Underground water is related to the structure of the strata.
>
> e. Strata are formed by the function of water, etc.

The result of the achievement test showed that 61.9 % of the pupils who were used as subjects were able to answer correctly the problems on the strata of the earth. It was stated by the teachers that so many schools in Japan oftenly allow their pupils to experience educational field trips to places where earth strata can be observed in order to know and understand different substances contained therein. However, the schools that are located in places far away from observable rock strata encounter much difficulty in making schedule and appropriate preparations for the trip. In this case, to enable pupils to supplement their knowledge of strata, the various supplementary materials such as beautifully illustrated textbooks and well-prepared television films could be utilized by the teachers in their classrooms. Teachers, as well as students, enjoy using varied audio-visual aids related to the earth strata.

It was therefore recommended that the pupils should be allowed to study about the structure of the surface of the earth as well as to consider the value of knowing the rocks found in the earth strata. The study of rocks should be introduced because the pupils usually possess the innate tendency of appreciating the beauty of rocks. It is therefore necessary to include the study of rocks at the grade six level of the elementary schools.

Concluding Remarks

The main purpose of the administration of the achievement test was to make an inquiry about the appropriateness of the science teaching contents currently offered for the grade six pupils in all the elementary schools in Japan. A questionnaire was administered to some elementary school teachers in order to acquire information for the basic recommendation they could provide regarding the current school content. The data gathered was used in making the necessary revisions in the curriculum. The newly revised curriculum would, in turn, be tried out for a period of three years, starting 1989 until 1992. The final implementation of the curriculum will start in 1992.

The data gathered from this study was therefore used as basis for revising the "Course of Study" in science. It has provided important data related to the findings taken by the nationwide evaluation testing which covered 1 % of the total pupil population designed to determine their present achievement.

The present study, therefore, has provided data supplementing the national evaluation made in Japan through the administration of achievement test for school children and questionnaire for school teachers. This kind of exercise is very important in maintaining the appropriateness of science contents with the cognitive, affective, and psychomotor development of the learners.

Chapter VII

SUMMARY AND CONCLUSIONS

The importance of science education in the wholesome educational program for precollege level schooling is known to most educators at the present generation. The condition has been brought about by the fact that adolescents, learners usually enrolled at the upper elementary and secondary school levels, possess and exemplify the real talent to understand principles in science. Their understanding of the various science concepts can be enhanced better if their reasoning skills as well as their science process skills could be developed through the utilization of their innate rational thinking capabilities. The Piagetian theory has maintained the idea that the cognitive development of adolescent learners usually undergo levels of maturity that included preoperational to concrete to formal thinking that resembles the growth characterizing physical maturity of the human beings. During the adolescence, the theory as stipulated by Piaget suggests that rapid reformation occur on the cognitive structure of the students. It was also stated by Hurd that two rapid reformations exist during the periods that included 0 through 3, and 10 through 15 years of the human development. It can be noted however that most teachers experience in the school the difficulty of ensuring the nurture of scientific literacy in all the students within an active and safe science learning environment. The understanding about the factor affecting the reasoning and process skills, which are considered important as scientific thinking skills, and the other cognitive and science education related factors is therefore necessary.

This research has the major purpose of determining the commonalities of the countries like Japan, Republic of Korea, Philippines, and United States, with regard to the performance patterns of the learners on the cognitive skills, which included reasoning and science process skills as affected and correlated to the different science education related factors. The different science education related factors included the out-of-school science experiences, motivation towards science processes, love for nature, and attitude towards science lessons. In relation with this, the effect of a laboratory centered inquiry program on laboratory skills, science process skills, and understanding of science knowledge in middle grades learners has been determined in this study. The importance of knowing the developmental levels of the learners has also been emphasized in order to ensure the acceptable utilization of a certain content of the curriculum of science with the cognitive levels of the learners.

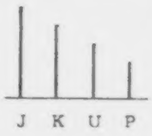
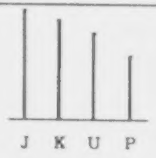
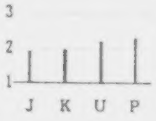
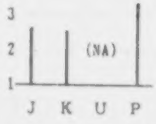
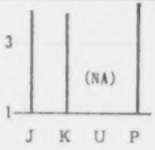
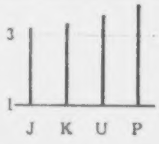
A. Summary of Findings

The major findings of this study were envisioned to be used by teachers and administrators in various countries in their endeavor to produce a science curriculum that could best fit the cognitive skills of the learners. This study is the first attempt made to survey the cognitive functioning of the learners in Japan, Republic of Korea, Philippines, and United States.

It can be gleaned from the data presented in Table 48 that

TABLE 48

SIMILARITIES AND DIFFERENCES AMONG JAPANESE, KOREAN, AMERICAN, AND PHILIPPINE STUDENTS (GRADE 7-9) IN TERMS OF THE CGNITIVE SKILLS AND OTHER STUDENTS CHARACTERISTICS

	Cognitive Skills in Science		Other Students Characteristics			
				Affective Characteristics		
	REASONING SKILLS	SCIENCE PROCESS SKILLS	OUT-OF-SCHOOL SCIENCE EXPERIENCE	MOTIVATION TOWARDS SCIENCE PROCESSES	LOVE FOR NATURE	ATTITUDE TOWARDS SCIENCE LESSONS
Total Group						
	·More performance discrepancy among the reasoning skills ·Sequential Development of skills	·Less performance discrepancy among the process skills ·Total Development of skills	·Relatively less out-of-school experience	(Inconclusive) ·Negative in Japan and Korea ·Positive in Philippines	·Positive love for Nature	·Positive attitude towards science lessons
	·Inter-correlation between reasoning skills and science process skills		Inter-correlation between science experience and affective characteristics			
	Significant relationship and correlation among cognitive skills, science experience, and affective characteristics					
Sex Differences	M > F* ·Males attained significantly higher performance than females.	(Inconclusive) ·Not significant in Japan and Philippines · M > F* in Korea · M < F* in U.S.	M > F* ·Males possessed significantly more out-of-school science experience than females.	(Inconclusive) ·M < F* in Korea and Philippines ·Not significant in Japan	M < F* ·Females felt significantly more positive love for nature than males.	(Inconclusive) ·M > F* in Japan, the U.S., and Korea ·M < F* in Philippines
Pattern of Grade Progress	8 < 9* · Japan, Korea, and the U.S. ↗ ·Philippines —↗	7 < 8 < 9* ↗ ·The upper grade students moved, the higher performance they attained.	(Inconclusive) ·Japan ↘ ·Korea and the U.S. ↘↗ ·Philippines ↗	8 < 9 ·Japan and Korea ↘↗ ·Philippines ↗	8 < 9 ·Japan ↘↗ ·Korea and Philippines ↗	(Inconclusive) ·Korea ↘ ·Japan and the U.S. ↘↗ ·Philippines ↗

the learners involved in the study from various countries exemplified several commonalities. It has been found out that on the bases of the total group result, the students from each country showed performance that could confirm the fact that the reasoning skills can undergo sequential developments. Not all of the subscales of the reasoning skills were able to present equal or consistent development in all the countries. It has also been found out that less performance discrepancy among the subscales of the process skills were demonstrated by the students from the four countries and the total development of the skills had been attained.

With regards to sex differences on the performance on the reasoning skills, it has been found out that the males attained significantly higher than the females in all the four countries. The science process skills, however, have not been found out to demonstrate similar pattern in all the countries because the males significantly acquired higher performance than the females in Republic of Korea, the females significanly acquired higher performance than the males in the United States, and the males and females did not exemplify significant differences with regard to their performance in the Philippines and Japan.

With regards to the pattern of grade progress on the performance of the cognitive skills, it has been found out in the study that the grade level of the students affected their capacity to perform successfully in solving the reasoning skills and science process skills in all the countries. It has been found out in the study that as the learners progress in their grade levels, it is more likely that their performance would also increase. However, the students from the Philippines seemed to have demonstrated no performance differences on their reasoning skills during Grade 7 and Grade 8.

It has also been found out that the students from the four countries acquired relatively low out-of-school experiences related to science. With regards to the sex differences, it has been found out that the males possessed significantly more out-of-school science experiences than the females. With regards to the patter, however, the different countries showed varied patterns. As the students in Japan proceed to the higher grade levels, their out-of-school experiences in science showed a declining tendency. The students from the Philippines exemplified the opposite pattern compared to the students from Japan because as they move in the higher grade levels, their out-of-school experiences also showed a remarkable trend of increase. The students from Republic of Korea and United States acquired similar pattern that depicted the decreasing and then the increasing tendency of their out-of-school experiences within the 3 year school levels.

The motivation towards science processes in the four countries, which excludes the United States due to the inavailability of data, suggest the tendency of being inconclusive. It has been found out in the study that the students in Japan and Republic of Korea acquired negative tendency as to their feeling of being motivated to deal with the science processes is concerned. On the other hand, the students in the Philippines exemplified being positive on their attitude to deal with the different science processes assessed in this study.

The sex differences of the students has also been found out in the study to be inconclusive among the 3 countries--Japan, Republic of Korea, and Philippines. No significant differences has been found out to be caused by the gender of the students in Japan with regards to their feeling of having been motivated to perform the different science processes.

With regard to the grade level pattern, the data from the Philippines suggest that students demonstrated more positive motivation towards science processes as they progress in their grade levels. This tendency has been found out to be lacking from the students in Japan and South Korea because the fluctuating tendency of their motivation towards science has been observable within the period of the 3 grade levels.

All the three countries--Japan, Republic of Korea, and Philippines--exemplified commonality of the existence of positive love for nature among the students. The females in these countries also felt significantly more positive love for nature than the males. The analysis of the pattern of grade progress with regard to the love for nature suggest that the students from Republic of Korea and the Philippines exemplified the direct influence of the grade level towards the positive feeling they have demonstrated. On the other hand, the students from Japan depicted the declining tendency of their love for nature during the period of Grade 8, and then the upward tendency has appeared again during the Grade 9 period.

The four countries exemplified commonalities on the existense of positive attitude towards science lessons among the student populace used as subjects of this study. There was the existence of inconclusiveness with regard to the influence of sex differences on the feeling of positive attitude towards science lessons. The finding in this study suggests that the males depicted significantly more positive attitude towards science lessons than the females in countries like Japan, United States, and Republic of Korea. The female students in the Philippines, however, exemplified significantly more positive attitude toward science lessons than the male students. The pattern of grade progress also depicted inconclusiveness because the declining tendency has been depicted by students in Republic of Korea on their attitude towards science lessons as they progress along the different grade levels. That result is the opposite of the finding observed from the data provided by the students in the Philippines. The data in the United States and Japan depicted the fluctuating tendency of the students` attitude towards science lessons within the 3 grade levels.

The different countries, which included Japan, Republic of Korea, Philippines, and United States, showed commonalities with regards to the performance of the students on the cognitive skills such as on the reasoning skills and science process skills, and on the experiences related to science while out of school, and on the feeling of being motivated towards science processes, feeling of love for nature, and attitude towards joining science lessons.

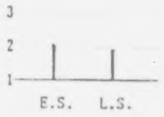
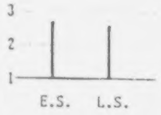
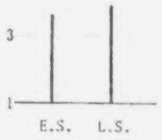
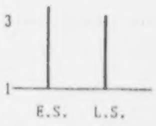
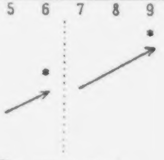
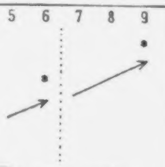
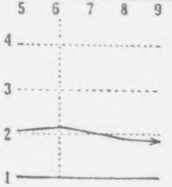
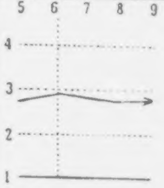
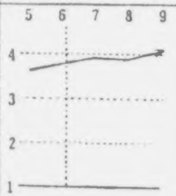
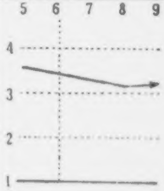
The cognitive skills in science as well as the other characteristics of the elementary school pupils in Japan have been presented in a summarized form in Table 49. The finding of the study as depicted in the table also provided the data taken from the lower secondary schools in Japan in order to show the continuity of the progress nade by the learners within a span of 5 years.

The findings of the study with regard to the total group performance of the elementary school pupils on the cognitive skills had been found out to be consistent with the result acquired from the secondary school levels in Japan. The reasoning skills of the pupils showed more performance discrepancy among the reasoning skills and therefore the sequential development of the different subscales has been found out to be demonstrated by the elementary pupils utilized in the study in Japan. The science process skills depicted the fact that lesser performance discrepancy among the process skills has been garnered by the elementary school pupils, and so the total development of skills has been found out to exist in this study.

With regards to sex differences, it has been found out that among the elementary school pupils in Japan, the male pupils attained significantly higher performance than the females on the reasoning skills. On the contrary, the females acquired significantly higher performance than the males with regards to the science process skills. This finding on the science process skills was found out to be the opposite of the finding acquired

TABLE 49

SIMILARITIES AND DIFFERENCES AMONG UPPER ELEMENTARY (GRADES 5 AND 6) AND LOWER SECONDARY (GRADES 7 TO 9 SCHOOL STUDENTS IN JAPAN IN TERMS OF THE COGNITIVE SKILLS AND OTHER STUDENTS CHARACTERISRICS

	Cognitive Skills in Science		Other Students Characteristics			
	REASONING SKILLS	SCIENCE PROCESS SKILLS	OUT-OF-SCHOOL SCIENCE EXPERIENCE	Affective Characteristics		
				MOTIVATION TOWARDS SCIENCE PROCESSES	LOVE FOR NATURE	ATTITUDE TOWARDS SCIENCE LESSONS
Total Group	---	---				
	·More performance discrepancy among the reasoning skills ·Sequential Development of skills	·Less performance discrepancy among the process skills ·Total Development of skills	·Relatively less out-of-school experience	·Relatively negative motivation towards science processes	·Relatively positive love for Nature	·Relatively positive attitude towards science lessons
	·Inter-correlation between reasoning skills and science process skills		Inter-correlation between science experience and affective characteristics			
	Significant relationship and correlation among cognitive skills, science experience, and affective characteristics					
Sex Differences	M>F* ·Males attained significantly higher performance than females.	(Inconclusive) ·M<F• at Elementary level ·Not significant at Lower Secondary level	M>F* ·Males possessed significantly more out-of-school science experience than females.	(Inconclusive) ·M<F• at Elementary level ·Not significant at Lower Secondary level	M<F* ·Females felt significantly more positive love for nature than males.	M>F* ·Males showed significantly more positive attitude towards science lessons.
Pattern of Grade Progress	 ·The upper grade students moved, the higher performance they attained.	 ·The upper grade students moved, the higher performance they attained.				

from the data using the lower secondary school students in Japan because the males acquired significantly higher performance than the females on the same matter.

The pattern of grade progress as exemplified by the elementary school pupils in Japan on the reasoning and science process skills has also demonstrated similarity with the findings taken from the secondary school level. It has been found out that the reasoning skills performance results showed that as the pupils move to the upper grade levels, then the performance they projected seemed to show a sign of progress showing an increasing pattern. That finding is also similar to that of the science process skills of the secondary school learners.

The out-of-school science experiences of the elementary school pupils in Japan seemed to be higher than the experiences acquired by the lower secondary school students in the same country. The elementary pupils also exemplified the fact that the males significantly acquired more out-of-school science experiences than the females. The pattern or grade progress with regards to the out-of-school science experiences of the elementary school pupils suggests that a remarkable increase can be seen from Grade 5 to Grade 6. Extending the data using the out-of-school science experiences of the students at the secondary school level in Japan suggest that a declining tendency, which means the higher the grade level the learners are, then the fewer experiences related to science had been dealt by them. The pattern has been observable although the out-of-school science experiences of the elementary school pupils were found out to be relatively too low.

The motivation toward science processes of the elementary pupils in Japan has also been found out to exemplify the existence of relatively negative tendency based on the ratings they made on the different items of the opinionnaire on this matter. The lower secondary school students, however, possessed relatively lower motivation towards science processes than the elementary school pupils in Japan. With regards to the performance of the pupils as determined by the gender they possessed suggest that the female groups acquired significantly higher motivation towards science processes than the male groups. This has not been found out to have shown significant differences, however, if the data about the influence of sex differences from the secondary school level in Japan were to be scrutinized closely. The grade pattern of the motivation towards science processes suggests that an increasing tendency of the ratings made by the pupils has been found out between the Grade 5 and Grade 6 pupils of the elementary school level. The data from the secondary school level in Japan also depicted a remarkable tendency to decline as the learners proceed from the lower grade towards the higher grade levels.

Using the data of the total group of the elementary school pupils at the elementary school pupils in Japan, it would be possible to take note about the observation that the pupils possessed a relatively positive feeling towards loving nature. The data from the secondary school levels in Japan seemingly have presented the fact that the students at this level acquired the feeling comparatively higher that those demonstrated by the elementary school pupils. The female pupils at the elementary school levels in Japan have been found out to have felt more positive love for nature than the male pupils. It has been found out in the study, by using the samples from Japan, that the feeling towards loving nature increased along with the advancement towards the higher grade levels of the learners.

The attitude towards science lessons of the elementary school pupils in Japan depicted the existence of a relatively positive tendency which is similar to that of the secondary school students. The male pupils at the elementary school level were found ouf to possessed more positive attitude towards science lessons than the female pupils. It has also been found out in the study that the as the learners move from the lower grade levels to the higher grade levels, then the tendency of decline on their attitude towards science lessons has become a phenomenon.

It has been found out in the study, by using the data taken from the elementary school pupils in Japan and the data takem from the secondary schools from the four countries--Japan, Republic of Korea, Philippines, and United States--, that the reasoning skills and science process skills significantly related and correlated positively to the characteristics of learners which included the out-of-school science experieces, the motivation towards science processes, the love for nature, and the attitude towards science lessons. The reasoning skills and science process skills were also found out to possess significant relatinship as well as positive correlation with each other.

The similarities and differences in terms of the effect of instructional strategies in science among middle grades (Grade 6 and Grade 7) students in the United States have been presented in summary form in Table 50. It has been found out in the study that the laboratory skills, science process skills in specific context, and the total skills in science has significantly related to the inquiry approach. The inquiry approach has been found out to possess significant effects from the utilization of science process skills in general context and from knowledge and understanding in science in general contexts. It has been found out in the study that a laboratory-centered inquiry program (FAST) can enhance student total ability in science and especially laboratory skills and specific science process skills such as on graphing and interpreting data.

The assessment of science achievement in Grade 6 pupils in Japan has been made in the study in order to make possible the provision of recommendations that could be used on the revision of the science curriculum at the elementary school level. The subjects that were used in the assessement included elementary school pupils selected from various parts of the country. The summary of the findings on the assessment made in has been presented in Table 51.

It has been found out that some of the content of the present science curriculum in Japan need to be reoriented as to their appropriateness to the cognitive, affective, and psychomotor capacities that the pupils possess.

TABLE 50

SIMILARITIES AND DIFFERENCES AMONG MIDDLE GRADES STUDENTS (GRADES 6 AND 7) IN THE UNITED STATES IN TERMS OF THE EFFECTS OF INSTRUCTIONAL STRATEGIES IN SCIENCE

	Laboratory skills	Science Process Skills		Knowledge and Understanding in Science		Total Skills in Science
		in specific contexts	in general contexts	in specific contexts	in general contexts	
Significant effects favourable to inquiry approach	×	×		(Inconclusive) ·Significant at 6th grade		×
Significant effects favourable to textbook approach						
Not significant effects			×	(Inconclusive) ·Not significant at 7th grade	×	

TABLE 51

ASSESSMENT OF SCIENCE ACHIEVEMENT IN THE SIXTH GRADE PUPILS AND RECOMMENDATIONS FOR THE REVISION OF SCIENCE CURRICULUM IN JAPAN

Objectives and Contents at the 6th Grade in the Present Course of Study in Japan		Achievement Level (%)	Recommendations
A Living Things and Their Environment	(1) To make pupils understand that plants grow by influencing each other while examining the places where plants grow thickly.	% 78.4	This teaching content should be transferred to the lower grades because it is too easy for the 6th graders.
	(2) To make pupils, by examining the process of forming fruits from flowers, understand the relationship between pollination and fructification.	% 77.8	This content should be transferred and combined with the content on hatching of fish eggs presently included at the 5th grade.
	(3) To have pupils, by examining respiratory and digestive functions of the human body, understand outlines of the structure and function of the human body.	% 62.4	Other animals should be included in the study of the structure and functions of the human body. This content should be integrated with the content on the structure and functions of plants and animals presently included at the 3rd grade.
B Matter and Energy	(1) To make pupils understand the properties of the water solution while examining dissolved substance in water.	% 66.2	The neutralization process as one of the chemical reactions and changes should be added to this content because it arouses pupils' curiosity and interest.
	(2) To make pupils, by examining the state of a substance burnt with a flame, understand that a flame is produced when gas is burnt.	% 62.9	The function and value of air in combustion of substances should be added to this content. A study on iron as a substance should also be included.
	(3) To have pupils understand how objects are heated while examining changes of substances when heated.	% 71.1	This content should be transferred to the grade four. It should be combined with the content on the volume change and the effect of temperature. The topic related to the density should be transferred to the higher school levels.
	(4) To make pupils, by using a lever and examining the points where the force is applied and the magnitude of the force applied, understand the principles of a lever and some tools to which the principles of a lever are applied.	% 62.4	This content is just fitted for grade six pupils because they are interested with the lever phenomenon. To strengthen the quantitative thinking skills, it could be possible to transfer this content to the grade five.
	(5) To have pupils, by making an electromagnet and examining magnetic force and magnetic poles, understand the function of the electromagnet.	% 75.7	The actual application of electromagnetism concepts should be emphasized by including the manipulative and practical activities. The pupils seem to have shown enjoyment dealing with this task.
C The Earth and The Universe	(1) To make pupils understand the reasons for the changes of atmospheric temperature in different seasons, while examining the altitude of the sun and the changes of atmospheric temperature in different seasons.	% 62.5	The pupils encountered difficulty in understanding the seasonal changes. The task of recording seasonal changes seems to be not so attractive to them. This content should be transferred to the lower secondary school level.
	(2) To have pupils understand that some of strata formation are the results of the function of running water, etc., while examining the way of forming the strata of the earth and composition of the strata.	% 61.9	The pupils should be allowed to study about the structure of the surface of the earth as well as to consider the value of knowing the rocks found in the strata. The content on rocks should be introduced also in this study.

B. Conclusions

Based on the aforementioned findings of the study related to the cognitive skills and the related science education variables, the following conclusions were made by the investigators:

The cross-cultural survey undertaken to assess the cognitive functioning, affective characteristics, and experiences of the secondary school students in Japan, Republic of Korea, Philippines, and United states brought about the fact that although the environmental conditions surrounding the learners in different contexts exist, it could still be possible to delineate commonalities in relation to the development of scientific thinking skills among learners. The developmental process of cognition among the students were found out to be directly related to the experiences and affective characteristics that they possess.

As has been acquired from the data taken from the secondary school levels, the tendency of the pupils at the elementary school levels were found out to project commonality with the specific features related to the different grades levels with regard to the cognitive skills, affective characteristics, and experiences related to science. Although the grade levels of the subjects utilized in the study differ, due to the inclusion of elementary and secondary school learners, it can be concluded that commonalities among the subjects exist on the way scientific thinking skills develop and that these developments occuring concomitantly on their cognitive facets are directly affected by their experiences and affective characteristics.

The study has also anwered the question related on how cognitive skills in science can be improved through the utilization of appropriately structured science instruction. It can be concluded that the laboratory centered inquiry approach has edge over the traditional textbook centered instruction with regard to the development of process skills, laboratory skills, and undestanding of scientific knowedge. It has been found out in the study, by using samples from the middle schools in the United States, that the traditional textbook approach has not shown significant effect on the cognitive skills in science.

It was found out in the section of the study about the assessment of the appropriateness of science curriculum content that it is necessary to consider the cognitive, affective, and psychomotor facets of the elementary school pupils in order to enable their acquisition of knowledge and understanding about the different science concepts. The data taken in Japan suggest that there is a felt need of evaluting the contents of the curriculum on the basis of their appropriateness to use at a certain grade level. If found to be inappropriate, the content must be transferred to the grade level in which the capacity of the learners to assimmilate it would be sufficient in due consideration of their developmental levels.

The conclusions presented in this report were gathered by means of using varied research methodologies. The cross-cultural data from Japan, Republic of Korea, United States and Philippines were gathered by using the descriptive method of research in the form of making a survey about the cognitive skills, characteristics, and experiences of the learners. The data about the elementary school pupils in Japan were also gathered in a similar way. The effects of instructional strategies in science among the middle grades students in the United States were gathered using the experimental method of research. The assessment of science achievement that has been used for determining the appropriateness of the content of the science curriculum at the elementary school level in Japan made used of the descriptive method of research by means of conducting a survey. In order to construct the theoretical framework related to curriculum development in science, the utilization of various methods of research is inevitable due to the fact that the capacity of the learners to learn effectively could be enhanced if an understanding about the different facets important in the development of cognition is made available from various sources throughout the world. Hopefully, the baseline data presented in this report could be utilized for the improvement of the quality of the teaching-learning process geared toward the achievement of educational excellence in the future.

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Appendix 1

ADDITIONAL BASELINE DATA ON THE COGNITIVE SKILLS AND CHARACTERISTICS OF LOWER SECONDARY SCHOOL STUDENTS

TABLE 52

DEVELOPMENTAL LEVEL DISTRIBUTION OF STUDENTS IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES

	JAPAN	KOREA	U.S.	PHILIPPINES
Concrete Level (0- 4)	31.8	46.3	69.3	89.7
Transitional Level (5- 7)	36.4	34.4	21.8	9.6
Formal Level (8-12)	31.8	19.3	9.3	0.7

TABLE 53

DEVELOPMENTAL LEVELS OF STUDENTS IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY SEX

	JAPAN		KOREA		U.S.		PHILIPPINES	
	Male	Female	Male	Female	Male	Female	Male	Female
Concrete Level (0- 4)	29.2	34.5	38.4	54.5	66.3	70.8	84.2	93.7
Transitional Level (5- 7)	34.5	38.5	36.1	32.6	21.5	22.7	14.3	6.3
Formal Level (8-12)	36.2	27.0	25.5	12.9	12.1	6.7	1.5	0.1

TABLE 54

DEVELOPMENTAL LEVELS OF STUDENTS IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE LEVEL

	JAPAN			KOREA			U.S.			PHILIPPINES		
	7th	8th	9th	7th	8th	9th	7th	8th	9th	7th	8th	9th
Concrete Level (0- 4)	40.3	32.0	23.2	59.0	53.4	27.5	78.5	69.0	60.8	96.2	94.2	87.1
Transitional Level (5- 7)	37.6	36.8	35.0	31.7	33.4	38.0	16.7	22.2	26.5	3.8	5.5	12.9
Formal Level (8-12)	22.1	31.2	42.0	9.3	13.2	34.5	4.9	9.5	12.8	0.0	0.2	0.0

TABLE 55

CORRECT RESPONSES IN EACH GALT SUBSCALE IN PERCENT

	JAPAN	KOREA	U.S.	PHILIPPINES
GALT Total	50.1	42.0	30.6	20.8
G1 Conservation	70.6	60.6	60.8	42.1
G2 Proportional Reasoning	53.1	42.0	16.9	14.5
G3 Controlling Variables	50.7	35.5	27.0	13.8
G4 Probabilistic Reasoning	41.6	37.5	16.7	4.3
G5 Correlational Reasoning	8.5	9.3	8.6	3.8
G6 Conbinatorial Reasoning	76.3	67.3	53.3	46.2

TABLE 56

CORRECT RESPONSES IN EACH GALT SUBSCALE IN PERCENT BY GRADE

	JAPAN			KOREA			U.S.			PHILIPPINES		
	7th	8th	9th	7th	8th	9th	7th	8th	9th	7th	8th	9th
GALT Total	44.8	49.9	55.6	35.6	38.5	51.5	26.4	30.8	34.3	17.3	18.3	22.3
G1 Conservation	67.2	72.7	71.8	60.8	56.1	64.6	59.0	60.5	63.0	32.8	41.1	43.5
G2 Proportional Reasoning	44.5	52.9	61.5	35.2	33.2	56.9	12.0	17.5	21.0	7.9	10.3	17.4
G3 Controlling Variables	42.9	50.9	58.2	24.5	33.4	48.0	22.5	26.5	32.0	10.7	11.5	13.8
G4 Probabilistic Reasoning	32.9	40.7	51.0	27.7	31.1	53.0	10.0	18.0	21.5	4.5	3.5	5.5
G5 Correlational Reasoning	8.1	8.0	9.4	8.5	9.8	9.5	7.5	9.5	8.5	6.2	3.7	1.8
G6 Conbinatorial Reasoning	73.1	74.3	81.6	56.8	67.4	77.3	47.5	52.5	60.0	41.6	39.4	51.7

TABLE 57

CORRECT RESPONSES IN EACH GALT SUBSCALE IN PERCENT BY SEX

	JAPAN		KOREA		U.S.		PHILIPPINES	
	Male	Female	Male	Female	Male	Female	Male	Female
GALT Total	52.0	48.1	46.1	37.8	32.8	29.5	22.7	19.5
G1 Conservation	75.0	65.9	67.9	53.0	66.6	57.9	44.6	40.4
G2 Proportional Reasoning	57.4	48.4	49.0	24.8	21.1	14.0	19.2	11.2
G3 Controlling Variables	50.2	51.3	36.6	34.4	26.8	28.1	15.2	12.9
G4 Probabilistic Reasoning	45.3	37.5	45.0	29.9	19.7	15.0	4.8	3.9
G5 Correlational Reasoning	8.6	8.4	9.1	9.5	10.2	7.3	4.4	3.5
G6 Conbinatorial Reasoning	75.6	77.2	69.1	65.6	52.3	54.9	48.0	44.9

TABLE 58

CORRECT RESPONSES IN EACH TIPS SUBSCALE IN PERCENT

	JAPAN	KOREA	U.S.	PHILIPPINES
TIPS Total	60.9	56.4	48.2	35.2
T1 Stating Hypothesis	49.3	47.7	46.9	32.2
T2 Identifying Variables	65.7	60.6	42.2	35.8
T3 Operationally Defining	61.6	53.4	52.7	34.7
T4 Desining Investigations	65.5	61.0	63.0	41.0
T5 Graphing Data	65.6	61.7	50.3	36.2

TABLE 59

CORRECT RESPONSES IN EACH TIPS SUBSCALE IN PERCENT BY GRADE

	JAPAN			KOREA			U.S.			PHILIPPINES		
	7th	8th	9th	7th	8th	9th	7th	8th	9th	7th	8th	9th
TIPS Total	57.1	59.8	65.6	53.7	56.6	58.8	46.1	47.2	53.1	28.7	34.1	38.6
T1 Stating Hypothesis	46.3	48.0	53.4	45.1	47.5	50.3	43.7	45.8	52.4	25.2	30.6	37.4
T2 Identifying Variables	62.3	65.0	69.8	57.9	61.5	62.6	39.8	41.3	45.7	30.2	36.0	38.4
T3 Operationally Defining	57.0	58.9	68.7	50.1	52.9	56.9	47.8	51.5	58.7	28.5	34.6	35.8
T4 Desining Investigations	61.3	65.0	70.0	58.6	61.9	62.5	59.0	61.7	68.3	36.4	38.4	45.1
T5 Graphing Data	60.8	65.5	70.3	59.2	61.5	64.4	45.5	49.5	55.7	27.3	32.9	40.4

TABLE 60

CORRECT RESPONSES IN EACH TIPS SUBSCALE IN PERCENT BY SEX

	JAPAN		KOREA		U.S.		PHILIPPINES	
	Male	Female	Male	Female	Male	Female	Male	Female
TIPS Total	60.9	60.9	57.7	55.0	47.9	49.2	35.4	35.1
T1 Stating Hypothesis	49.0	50.0	50.2	45.1	46.1	49.3	32.2	32.3
T2 Identifying Variables	65.1	66.4	60.3	61.0	41.1	43.4	35.5	36.0
T3 Operationally Defining	63.0	60.0	55.7	51.0	52.9	53.0	35.5	34.0
T4 Desining Investigations	65.5	65.6	62.2	59.7	62.7	64.3	42.7	40.0
T5 Graphing Data	66.1	65.0	63.8	59.7	51.8	49.5	36.6	35.8

TABLE 61

CORRECT RESPONSES IN EACH GALT SUBSCALE IN PERCENT BY DEVELOPMENTAL LEVEL

	JAPAN			KOREA			U.S.			PHILIPPINES		
	C	T	F	C	T	F	C	T	F	C	T	F
G1 Conservation	48.5	72.5	90.5	44.1	67.7	87.5	49.0	85.7	93.3	38.2	75.2	86.4
G2 Proportional Reasoning	16.9	54.2	87.9	15.3	52.3	87.5	6.6	28.8	64.7	9.2	58.7	95.4
G3 Controlling Variables	15.0	51.4	85.6	14.9	39.2	77.9	12.4	51.3	80.5	10.1	42.9	95.4
G4 Probabilistic Reasoning	6.1	35.3	84.3	8.5	47.6	88.9	3.0	30.5	90.8	3.5	11.6	9.1
G5 Correlational Reasoning	4.3	7.1	14.4	7.7	8.6	14.2	4.8	11.3	31.5	3.6	4.5	31.8
G6 Combinatorial Reasoning	55.3	80.2	93.0	51.1	75.7	91.6	40.9	78.0	89.2	41.8	83.6	95.4

TABLE 62

CORRECT RESPONSES IN EACH TIPS SUBSCALE IN PERCENT BY DEVELOPMENTAL LEVEL

	JAPAN			KOREA			U.S.			PHILIPPINES		
	C	T	F	C	T	F	C	T	F	C	T	F
T1 Stating Hypothesis	37.8	48.4	51.8	38.8	50.9	63.8	40.1	59.1	72.7	30.6	46.6	54.5
T2 Identifying Variables	51.3	67.0	78.6	52.5	64.6	73.8	38.5	47.3	57.6	34.6	46.4	51.5
T3 Operationally Defining	46.0	62.0	76.7	43.7	56.7	71.5	44.8	65.5	81.3	33.1	47.6	56.0
T4 Designing Investigation	49.3	65.7	81.3	51.3	63.9	79.5	54.5	78.1	90.1	39.2	57.0	63.6
T5 Graphing Data	51.0	65.8	79.8	51.5	65.9	78.9	42.4	64.6	75.3	33.9	55.0	69.7

TABLE 63

ATTITUDE TOWARD SCIENCE LESSONS MEAN IN ALL ITEMS

	JAPAN	KOREA	U. S.	PHILIPPINES
Total	3.22	3.28	3.55	3.89
1	3.07	3.39	3.87	3.64
2	3.41	3.65	4.10	4.20
3	3.14	3.11	3.55	4.19
4	3.08	2.90	3.49	3.96
5	3.01	2.80	2.95	3.33
6	3.38	3.61	3.38	3.94
7	3.51	3.83	3.74	3.76
8	3.59	3.71	3.78	3.91
9	3.01	2.87	3.49	3.98
10	3.19	3.38	3.84	3.66
11	3.12	2.92	3.30	3.93
12	3.54	3.87	3.73	4.10
13	3.39	3.79	3.61	3.62
14	3.06	2.99	3.47	4.12
15	2.99	2.88	3.10	4.00
16	3.43	3.46	3.79	3.55
17	3.65	3.84	3.90	4.00
18	2.81	2.67	2.50	3.46
19	2.99	2.85	3.29	3.87
20	3.00	3.04	3.39	4.02

TABLE 64

ANALYSIS OF VARIANCE MATRIX OF ALL GALT SUBSCALES AND OUT-OF-SCHOOL SCIENCE EXPERIENCES ITEMS

NS:not significant
• p<0.05
•• p<0.01

	JAPAN All: df=116 Each: df= 4	KOREA All: df=116 Each: df= 4	U. S. All: df=58 Each: df= 2	PHILIPPINES All: df=116 Each: df= 4
Total	5.03••	3.93••	9.78••	2.53••
1	8.71••	17.49••	33.91••	11.12••
2	1.95NS	5.24••	11.70••	1.57NS
3	3.22••	2.31NS	1.12NS	1.16NS
4	12.15••	3.71••	42.63••	2.06NS
5	3.66••	0.31NS	11.26••	5.07••
6	5.62••	2.62•	16.61••	1.27NS
7	5.29••	10.05••	4.23•	0.51NS
8	6.23••	3.73••	18.01••	2.16NS
9	1.36NS	1.30NS	0.78NS	2.71••
10	0.34NS	2.76•	0.30NS	1.61NS
11	1.21NS	3.29••	7.26••	0.39NS
12	0.97NS	3.91••	5.24••	0.35NS
13	1.59NS	0.68NS	4.51•	0.87NS
14	2.17NS	6.34••	1.62NS	2.36NS
15	3.56••	2.34•	4.57•	0.19NS
16	3.43••	0.92NS	0.89NS	0.90NS
17	3.13••	1.22NS	39.55••	7.22••
18	4.12••	2.85•	3.57•	0.52NS
19	6.45••	4.90••	5.11••	1.23NS
20	5.63••	0.68NS	5.57••	1.76NS
21	13.45••	15.00••	4.33•	2.05NS
22	23.85••	2.10NS	0.45NS	1.40NS
23	0.41NS	1.10NS	2.65NS	1.71NS
24	9.73••	3.09•	31.86••	2.31NS
25	0.72NS	0.72NS	5.83••	5.37••
26	1.45NS	1.63NS	6.91••	0.32NS
27	6.19••	7.33••	8.72••	6.45••
28	3.26••	5.12••	3.10•	8.49••
29	6.07••	1.08NS	1.27NS	0.37NS

TABLE 65

ANALYSIS OF VARIANCE MATRIX OF ALL TIPS SUBSCALES AND OUT-OF-SCHOOL SCIENCE EXPERIENCES ITEMS

NS:not significant
• $p<0.05$
•• $p<0.01$

	JAPAN All: df=116 Each: df= 4	KOREA All: df=116 Each: df= 4	U. S. All: df=58 Each: df= 2	PHILIPPINES All: df=116 Each: df= 4
Total	6.59••	4.31••	10.29••	3.36••
1	16.15••	22.52••	51.43••	10.27••
2	7.77••	6.71••	4.08•	2.36NS
3	4.41••	3.01•	2.23NS	5.94••
4	9.46••	1.65NS	42.33••	0.85NS
5	8.03••	0.74NS	5.69••	2.92•
6	4.29••	4.80••	16.71••	2.27NS
7	10.63••	12.70••	2.17NS	6.93••
8	6.81••	0.96NS	19.56••	5.62••
9	1.65NS	2.17NS	0.24NS	7.25••
10	2.46•	1.18NS	3.29•	0.76NS
11	3.08•	0.20NS	1.18NS	0.72NS
12	2.88•	2.55•	4.41•	1.25NS
13	0.32NS	3.97••	3.61•	1.00NS
14	1.71NS	8.15••	0.14NS	0.90NS
15	4.87••	1.95NS	0.35NS	1.43NS
16	1.83NS	1.58NS	1.69NS	0.76NS
17	3.55••	2.35•	62.43••	12.66••
18	5.59••	4.03••	5.75••	0.88NS
19	7.54••	5.12••	9.05••	1.80NS
20	8.06••	1.40NS	10.92••	2.84•
21	18.26••	15.25••	6.34••	2.71•
22	25.50••	4.04••	0.89NS	2.21NS
23	2.02NS	0.92NS	2.00NS	1.47NS
24	9.29••	3.24••	26.35••	1.28NS
25	0.61NS	3.06•	11.49••	4.56••
26	1.35NS	2.35•	0.31NS	0.96NS
27	7.51••	2.78•	1.18NS	5.03••
28	5.62••	2.20NS	1.73NS	9.26••
29	9.77••	3.50••	0.75NS	0.45NS

TABLE 66

ANALYSIS OF VARIANCE MATRIX OF ALL GALT SUBSCALES AND MOTIVATION TOWARDS SCIENCE PROCESSES ITEMS

NS:not significant
• $p<0.05$
•• $p<0.01$

	JAPAN All: df=60 Each: df= 4	KOREA All: df=60 Each: df= 4	U. S.	PHILIPPINES All: df=60 Each: df= 4
Total	11.80••	5.34••		3.38••
1	41.85••	18.48••		6.95••
2	47.33••	22.07••		2.70••
3	20.28••	8.15••		2.82••
4	20.29••	5.97••		7.49••
5	3.56••	9.87••		2.02NS
6	7.62••	1.29NS		3.68••
7	4.14••	0.40NS	(Not available)	0.92NS
8	3.96••	0.15NS		3.07••
9	4.97••	4.34••		7.00••
10	7.09••	2.42•		1.41NS
11	3.19••	0.79NS		2.22NS
12	3.23••	2.99••		4.39••
13	5.70••	1.35NS		0.52NS
14	1.70NS	0.55NS		0.35NS
15	2.06NS	1.32NS		5.15••

TABLE 67

ANALYSIS OF VARIANCE MATRIX OF ALL TIPS SUBSCALES AND MOTIVATION TOWARDS SCIENCE PROCESSES ITEMS

NS:not significant
• $p<0.05$
•• $p<0.01$

	JAPAN All: df=60 Each: df= 4	KOREA All: df=60 Each: df= 4	U. S.	PHILIPPINES All: df=60 Each: df= 4
Total	15.69••	7.35••		5.97••
1	62.80••	19.77••		18.66••
2	66.95••	32.85••		4.01••
3	24.45••	20.03••		2.55•
4	28.61••	4.19••		22.01••
5	10.14••	15.40••		6.47••
6	7.88••	1.59NS		3.86••
7	6.44••	0.54NS	(Not available)	3.19•
8	10.61••	0.66NS		3.03•
9	3.89••	5.32••		9.93••
10	0.57NS	0.78NS		1.69NS
11	1.27NS	0.61NS		0.73NS
12	1.76NS	6.67••		2.29NS
13	4.67••	0.87NS		1.84NS
14	2.58•	0.33NS		1.93NS
15	1.74NS	0.67NS		7.32••

TABLE 68

ANALYSIS OF VARIANCE MATRIX OF ALL GALT SUBSCALES AND LOVE FOR NATURE ITEMS

NS:not significant
• p<0.05
•• p<0.01

	JAPAN All: df=16 Each: df= 4	KOREA All: df=16 Each: df= 4	U. S.	PHILIPPINES All: df=16 Each: df= 4
Total	13.60••	4.73••		5.80••
1	21.09••	4.49••		14.85••
2	23.02••	9.33••	(Not available)	5.80••
3	2.63•	0.33NS		0.96NS
4	7.66••	4.76••		1.59NS

TABLE 69

ANALYSIS OF VARIANCE MATRIX OF ALL TIPS SUBSCALES AND LOVE FOR NATURE ITEMS

NS:not significant
•• p<0.01

	JAPAN All: df=16 Each: df= 4	KOREA All: df=16 Each: df= 4	U. S.	PHILIPPINES All: df=16 Each: df= 4
Total	21.90••	6.10••		8.14••
1	40.93••	12.91••		24.50••
2	32.71••	6.16••	(Not available)	5.02••
3	8.09••	1.09NS		1.53NS
4	5.87••	4.24••		1.50NS

TABLE 70

ANALYSIS OF VARIANCE MATRIX OF ALL GALT SUBSCALES AND ATTITUDE TOWARDS SCIENCE LESSONS ITEMS

NS:not significant
• p<0.05
•• p<0.01

	JAPAN All: df=80 Each: df= 4	KOREA All: df=80 Each: df= 4	U. S. All: df=80 Each: df= 4	PHILIPPINES All: df=80 Each: df= 4
Total	7.38••	2.68••	3.05••	3.77••
1	10.05••	13.04••	12.49••	4.67••
2	30.95••	6.78••	2.03NS	10.67••
3	21.97••	2.14••	3.01•	6.99••
4	6.19••	4.62••	2.36NS	4.43••
5	0.83NS	1.75NS	1.49NS	4.62••
6	10.70••	3.15•	3.73••	8.28••
7	5.96••	0.87NS	3.46••	3.37••
8	7.12••	2.52•	1.64NS	6.29••
9	7.13••	1.23NS	2.37NS	5.25••
10	0.57NS	0.39NS	1.98NS	0.31NS
11	1.53NS	0.71NS	1.56NS	2.77•
12	1.81NS	1.56NS	0.97NS	4.29••
13	6.88••	1.55NS	9.93••	2.98•
14	3.86••	1.28NS	0.75NS	2.57•
15	5.44••	2.45•	3.35••	0.53NS
16	3.03•	1.85NS	1.25NS	1.51NS
17	11.28••	1.07NS	1.73NS	2.01NS
18	5.91••	5.56••	3.83••	0.14NS
19	2.13NS	0.55NS	1.86NS	3.14•
20	4.35••	0.45NS	1.18NS	0.56NS

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TABLE 71

ANALYSIS OF VARIANCE MATRIX OF ALL TIPS SUBSCALES AND ATTITUDE TOWARDS SCIENCE LESSONS ITEMS

NS:not significant
• p<0.05
•• p<0.01

	JAPAN All: df=80 Each: df= 4	KOREA All: df=80 Each: df= 4	U. S. All: df=80 Each: df= 4	PHILIPPINES All: df=80 Each: df= 4
Total	9.74••	3.42••	3.07••	6.58••
1	11.78••	11.24••	13.39••	14.46••
2	32.57••	14.14••	1.71NS	23.29••
3	42.30••	5.96••	4.47••	3.04•
4	9.56••	4.15••	2.55•	13.64••
5	2.17NS	1.97NS	0.45NS	14.13••
6	16.93••	4.93••	3.35••	12.45••
7	8.61••	0.76NS	5.11••	5.80••
8	10.97••	2.53•	1.97NS	12.37••
9	7.61••	0.85NS	2.06NS	3.61••
10	1.13NS	0.36NS	0.19NS	1.46NS
11	1.32NS	1.61NS	1.36NS	2.48•
12	2.64•	2.12NS	1.40NS	2.98•
13	6.34••	1.51NS	7.60••	7.62••
14	2.33•	2.20NS	0.49NS	3.36••
15	7.47••	3.07•	2.43•	0.70NS
16	3.43••	1.34NS	1.47NS	1.77NS
17	11.63••	1.02NS	5.85••	3.07•
18	10.14••	6.74••	3.34••	2.65•
19	2.56•	0.94NS	1.93NS	1.51NS
20	3.30••	0.93NS	0.20NS	1.19NS

TABLE 72

MULTIPLE ANALYSIS OF VARIANCE AND CORRELATION COEFFICIENT MATRIX OF COGNITIVE SKILLS AND FACTORS SUCH AS OUT-OF-SCHOOL SCIENCE EXPERIENCES, MOTIVATION TOWARD SCIENCE PROCESSES, LOVE FOR NATURE AND ATTITUDE TOWARDS SCIENCE LESSONS

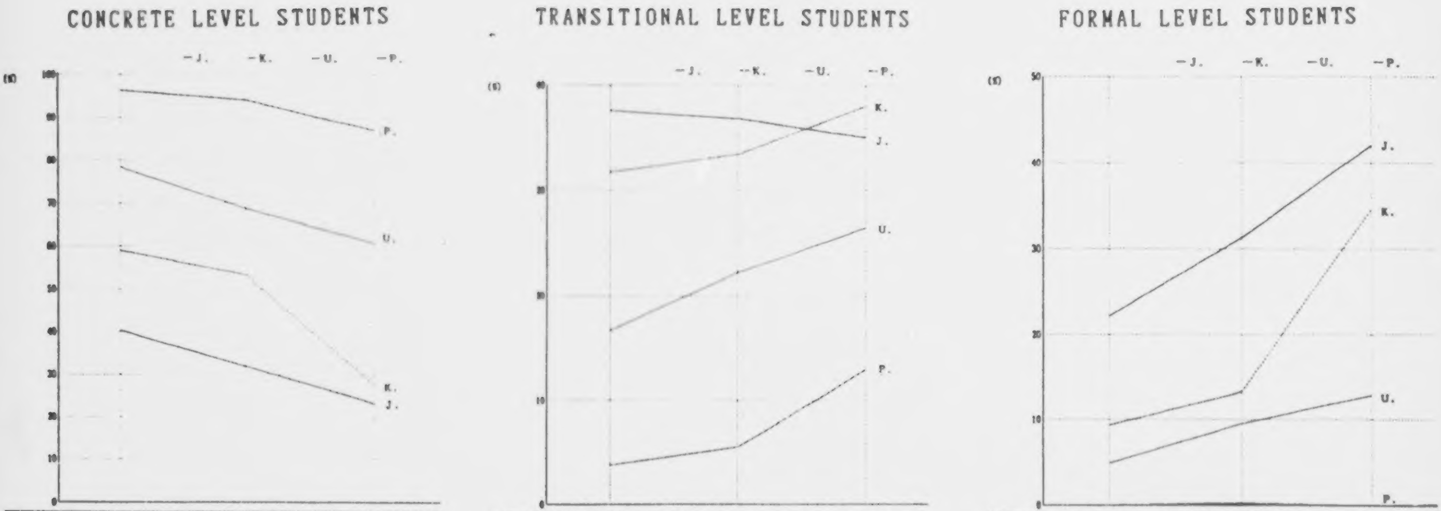
	JAPAN				KOREA				U. S.				PHILIPPINES			
	R. S.		P. S.		R. S.		P. S.		R. S.		P. S.		R. S.		P. S.	
	F	r	F	r	F	r	F	r	F	r	F	r	F	r	F	r
Science Experience out of School	•• 5.03	••• .08	•• 6.59	••• .10	•• 3.93	••• .16	•• 4.31	••• .18	••• 9.78	••• .14	••• 10.29	••• .15	•• 2.53	••• .19	••• 3.36	••• .21
Motivation toward Science Process	•• 11.80	••• .28	•• 15.69	••• .35	•• 5.34	••• .25	•• 7.35	••• .31	(not availble)				•• 3.38	••• .17	••• 5.97	••• .24
Love for Nature	•• 13.60	••• .16	•• 21.90	••• .22	•• 4.73	•• .11	•• 6.10	••• .15	(not availble)				•• 5.80	••• .18	••• 8.14	••• .26
Attitude toward Science Lessons	•• 7.38	••• .22	•• 9.74	••• .25	•• 2.68	••• .15	•• 3.42	••• .21	••• 3.05	••• .13	••• 3:07	••• .12	••• 3.77	••• .26	••• 6.58	••• .34

(R. S. :Reasoning Skills, P. S. :Process Skills)

•:p<0.05

••:p<0.01

•••:p<0.001



CONCRETE LEVEL STUDENTS

	7th	8th	9th
J.	40.3	32.0	23.2
K.	59.0	53.4	27.5
U.	78.5	68.0	60.8
P.	96.2	94.2	87.1

TRANSITIONAL LEVEL STUDENTS

	7th	8th	9th
J.	37.6	36.8	35.0
K.	31.7	33.4	38.0
U.	16.7	22.2	26.5
P.	3.8	5.5	12.8

FORMAL LEVEL STUDENTS

	7th	8th	9th
J.	22.1	31.2	42.0
K.	9.3	13.2	34.6
U.	4.8	9.5	12.8
P.	0	0.2	0

FIGURE 81

DEVELOPMENTAL LEVELS OF STUDENTS IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE LEVEL

FIGURE 82

DIFFICULTY INDEX AMONG GALT SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE AND DEVELOPMENTAL LEVELS

⟺ : *significant at p<.05*

— : *not significant*

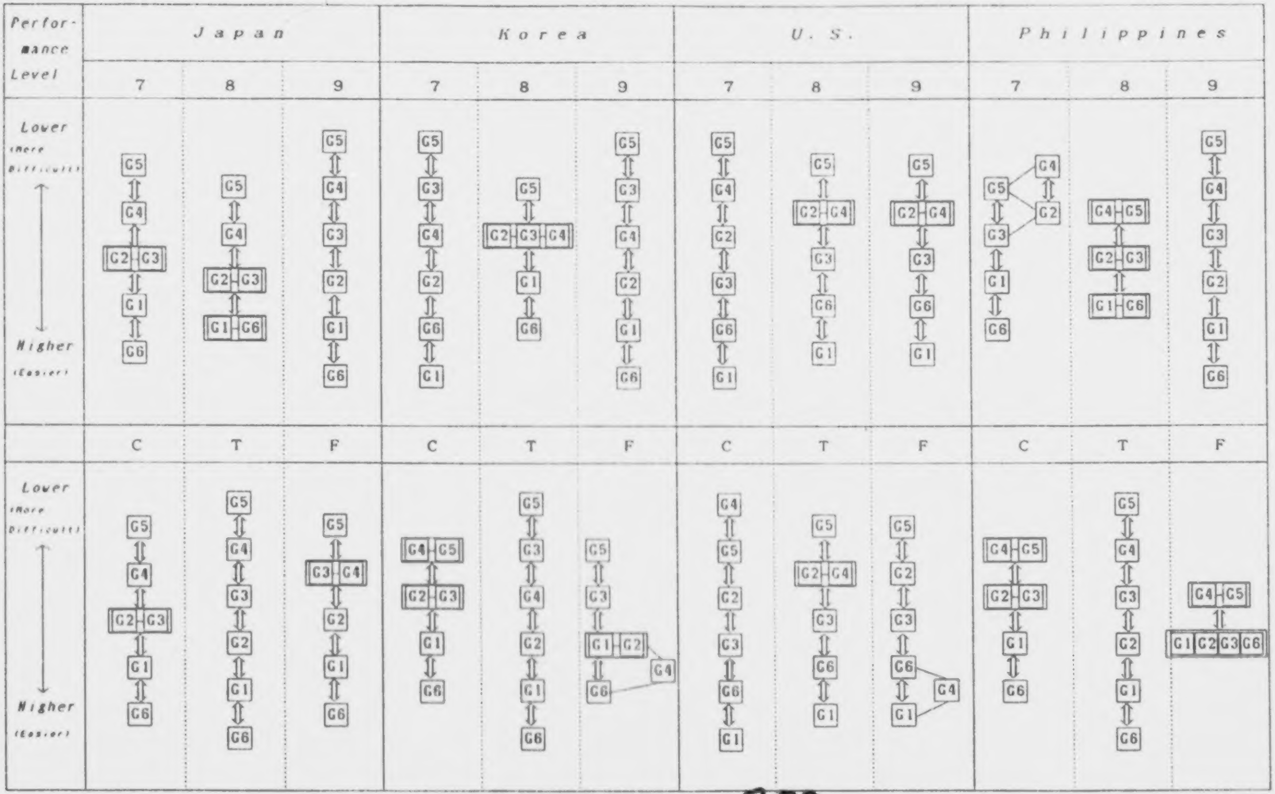
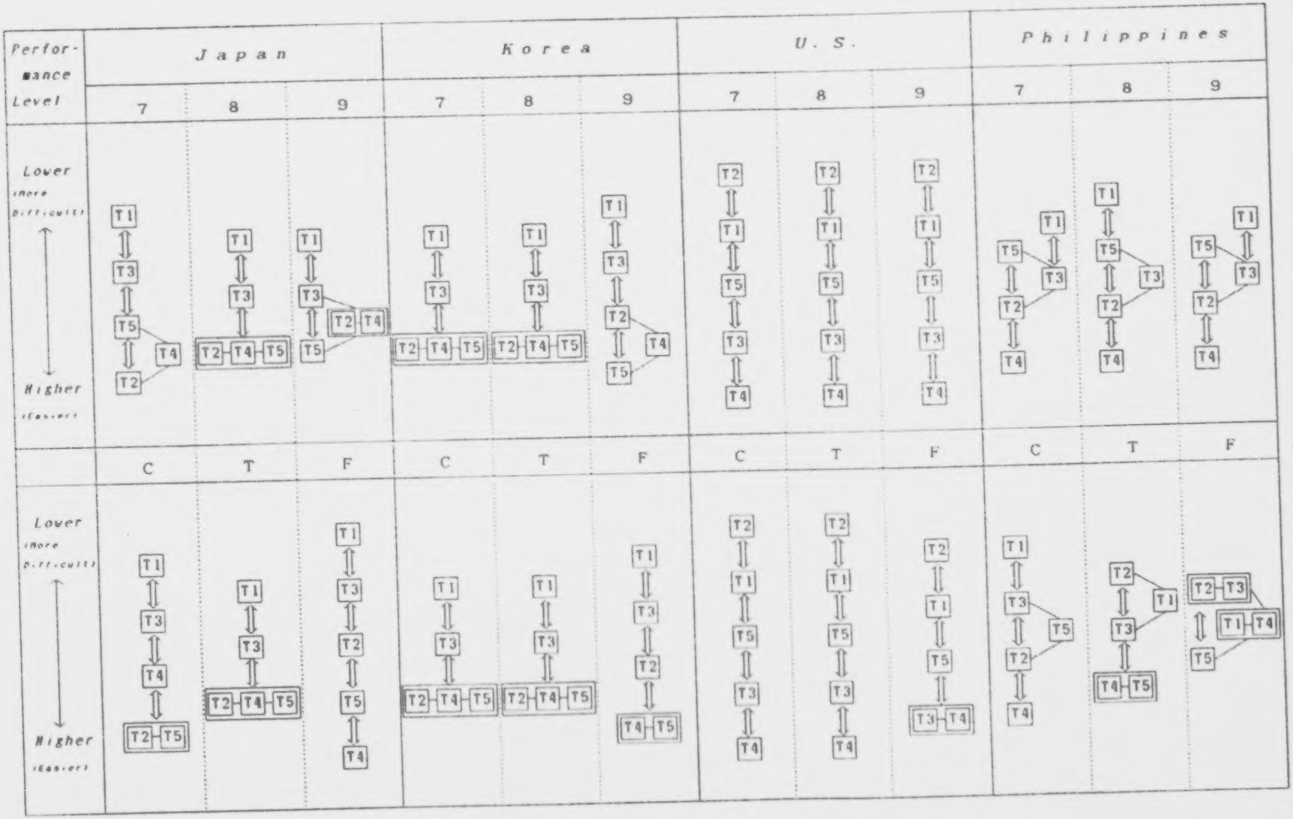

Perfor-mance Level
Japan
Korea
U. S.
Philippines
7
8
9
Lower (More Difficult)
Higher (Easier)
C
T
F
G1
G2
G3
G4
G5
G6

FIGURE 83

DIFFICULTY INDEX AMONG TIPS SUBSCALES IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY GRADE AND DEVELOPMENTAL LEVELS

⟺ : significant at p<.05

— : not significant


Performance Level
Japan
Korea
U. S.
Philippines
7
8
9
Lower (more Difficult)
Higher (Easier)
C
T
F

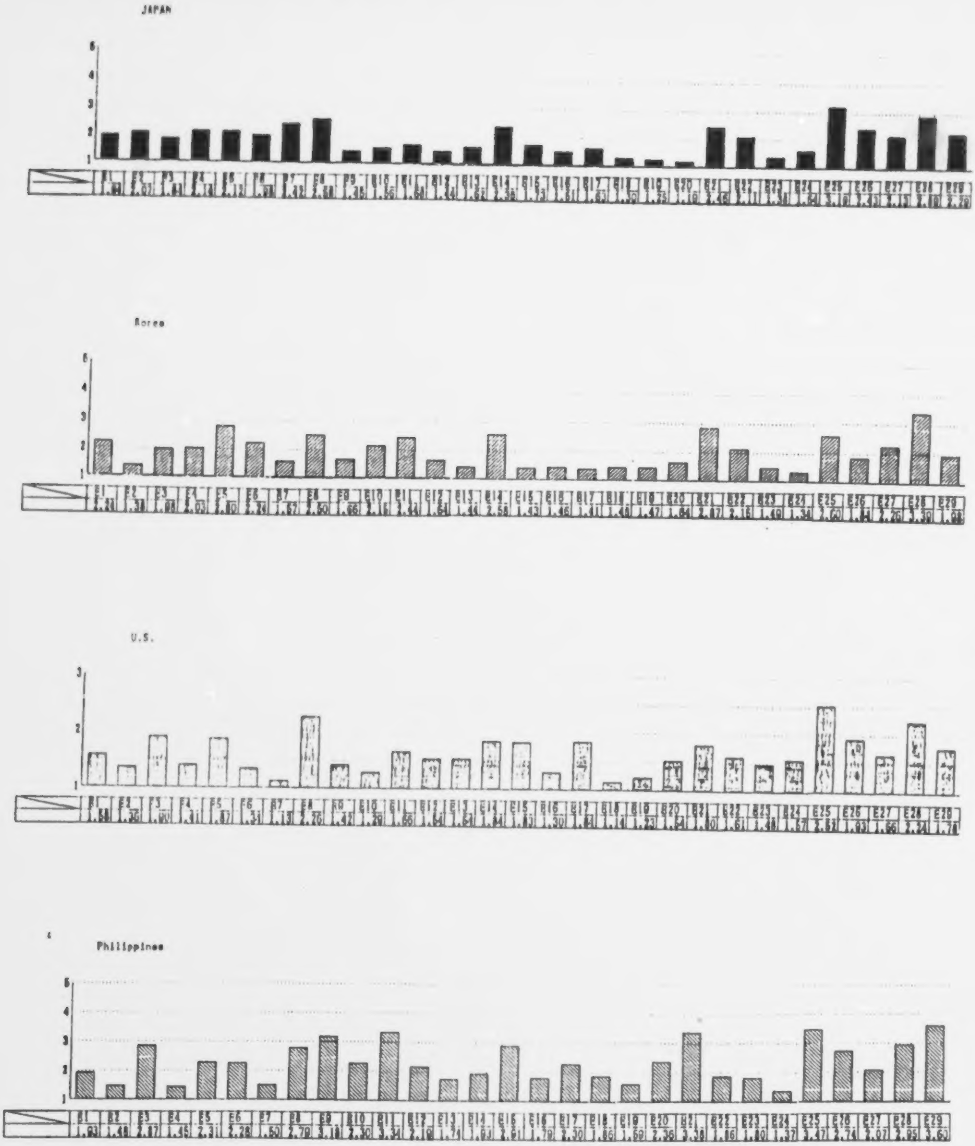


FIGURE 84

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES, BY ITEM

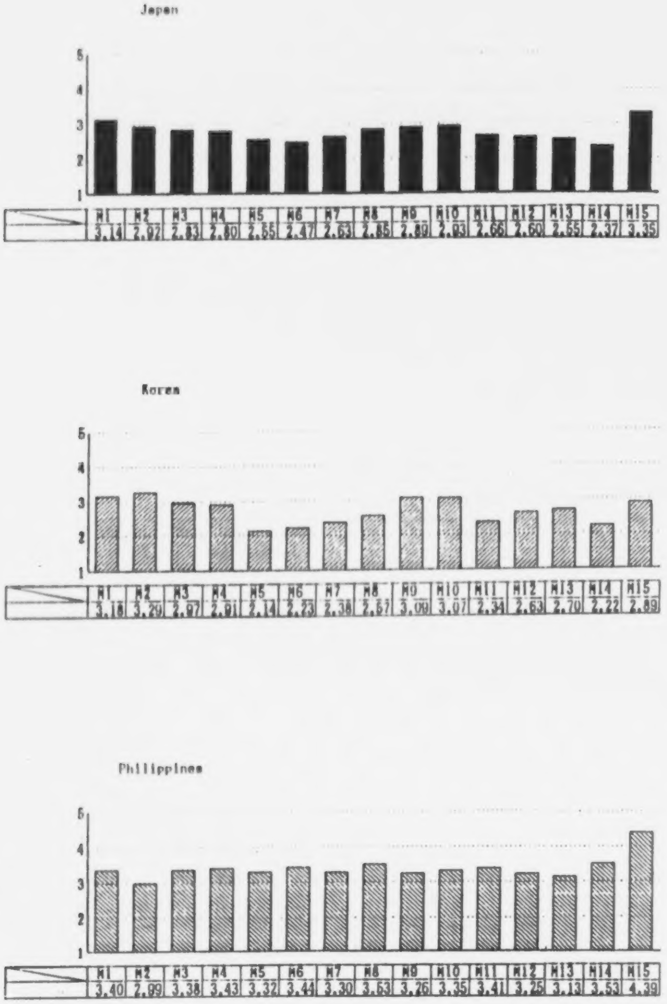


FIGURE 85

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY ITEM

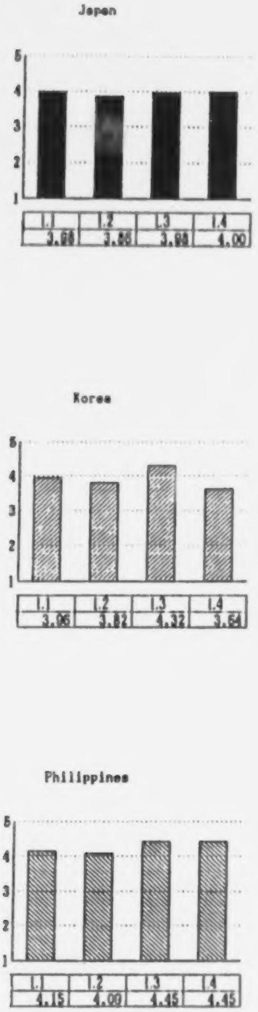


FIGURE 86

LOVE FOR NATURE MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES, BY ITEM

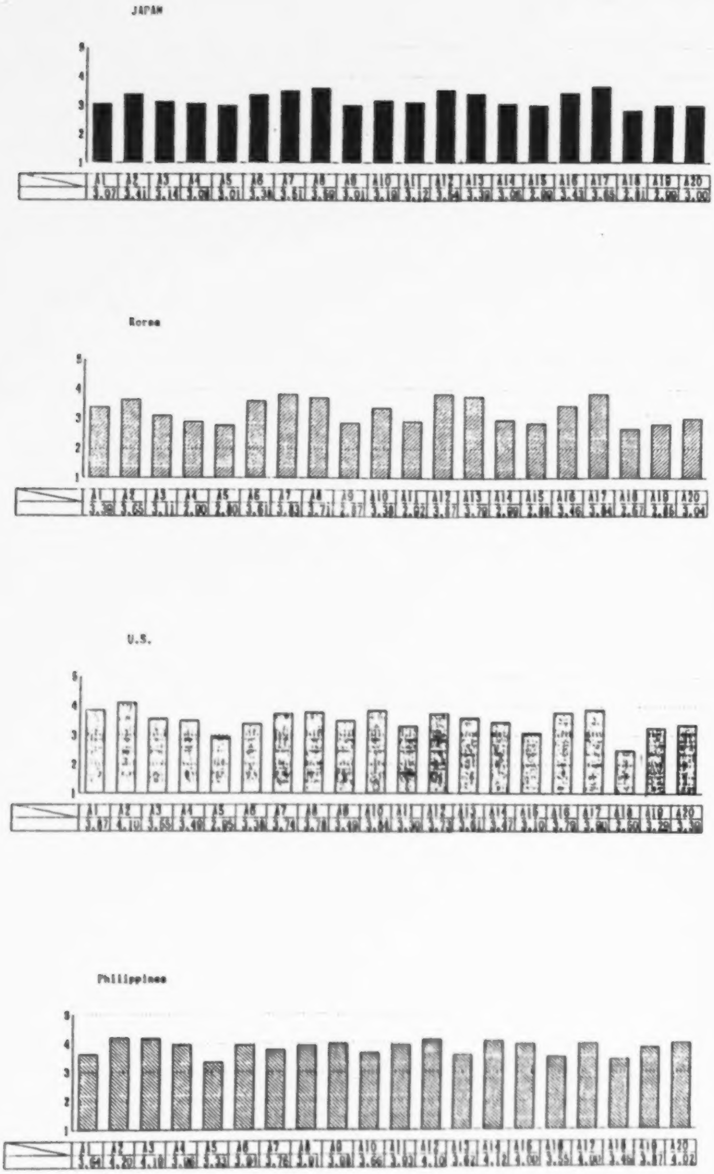
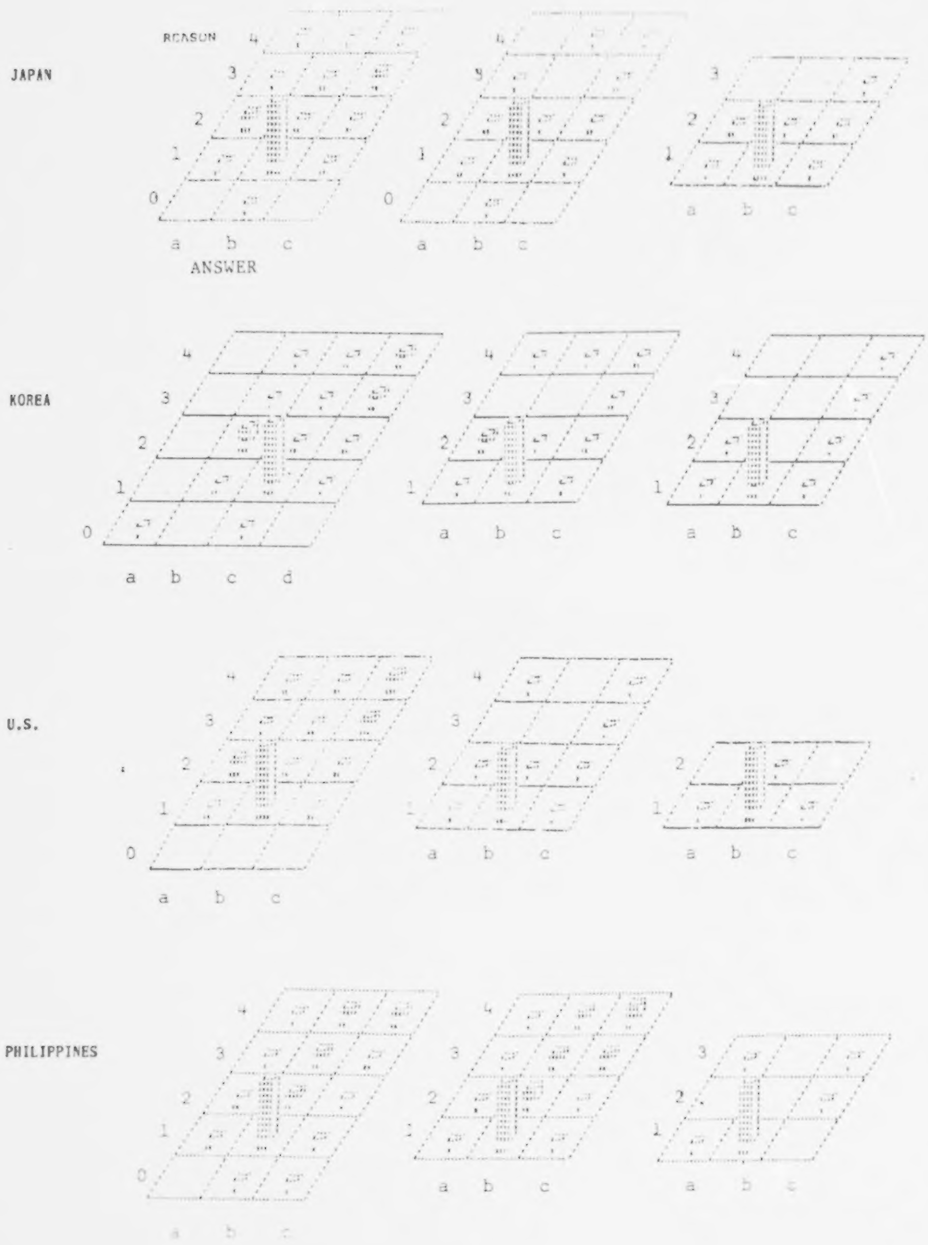


FIGURE 87

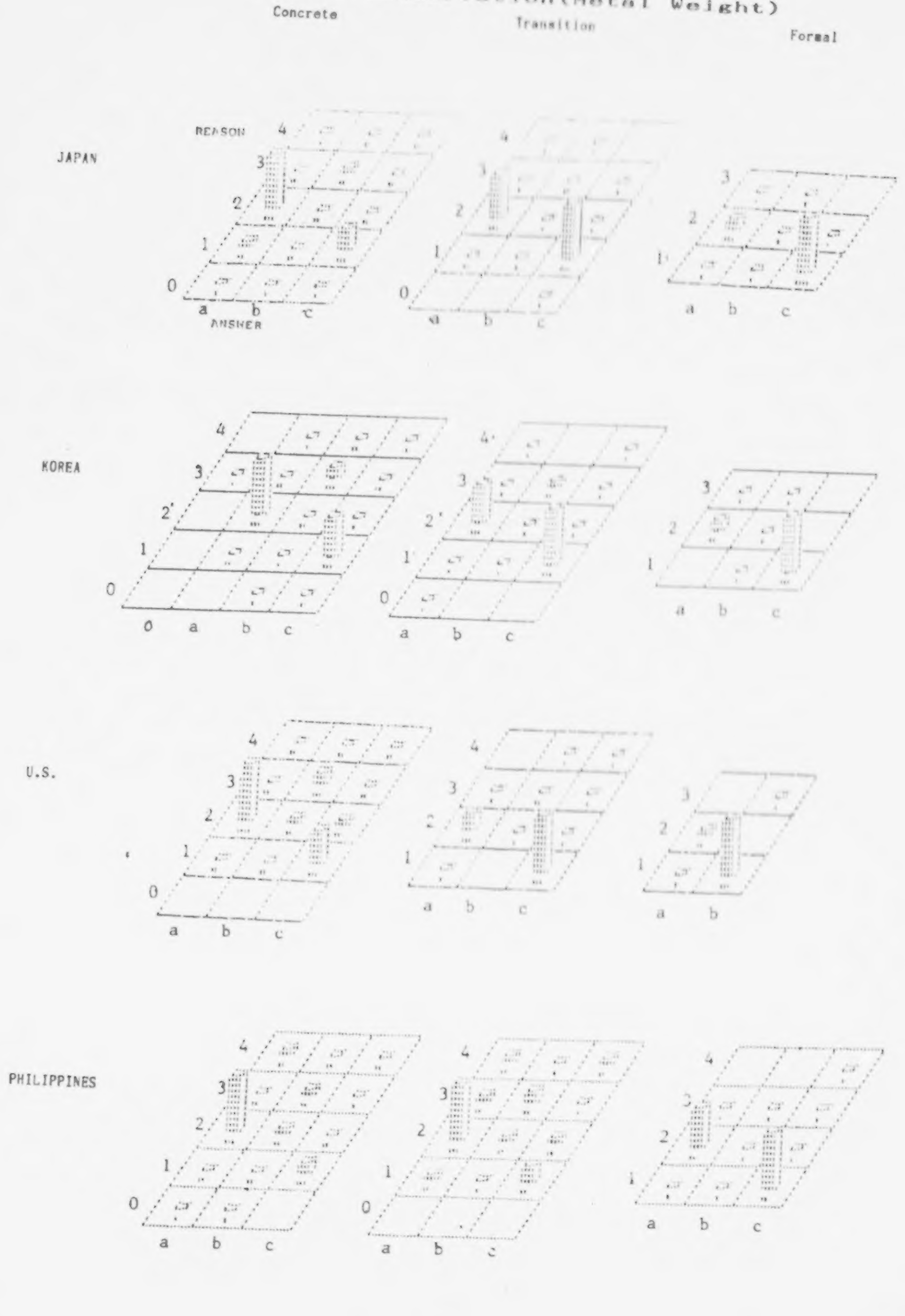
ATTITUDE TOWARDS SCIENCE LESSONS MEAN IN JAPAN, SOUTH KOREA, UNITED STATES, AND THE PHILIPPINES BY ITEM

Item 1:Conservation(Piece of Clay)

Concrete Transition Formal



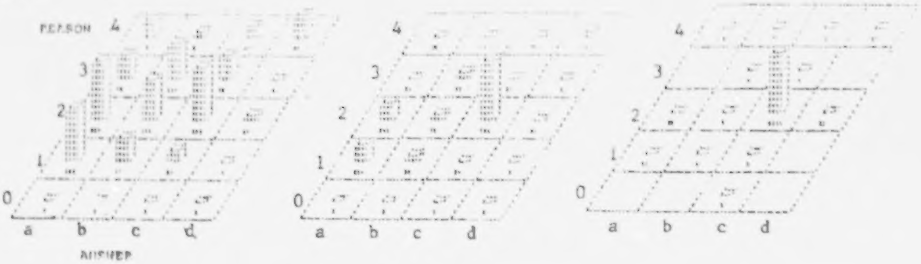
Item 2:Conservation(Metal Weight)



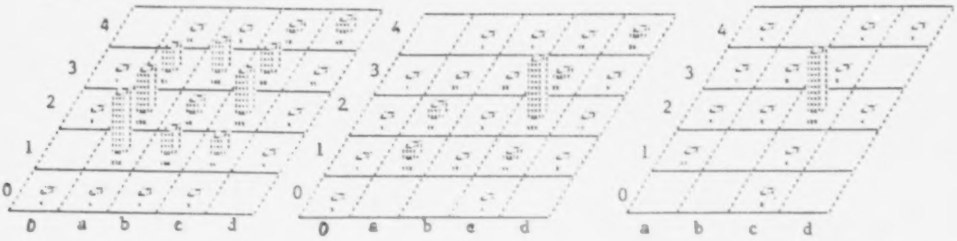
Item3:Proportional Reasoning(Glass Size #2)

Concrete Transition Formal

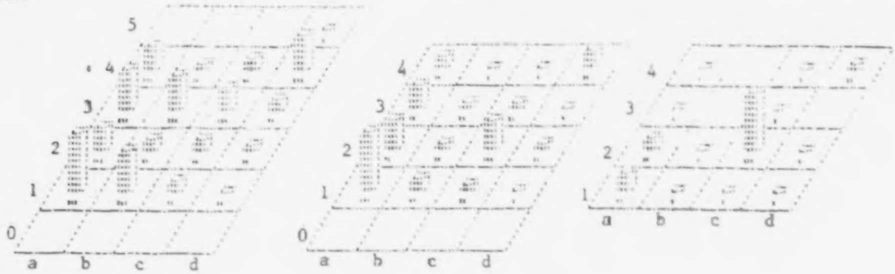
JAPAN



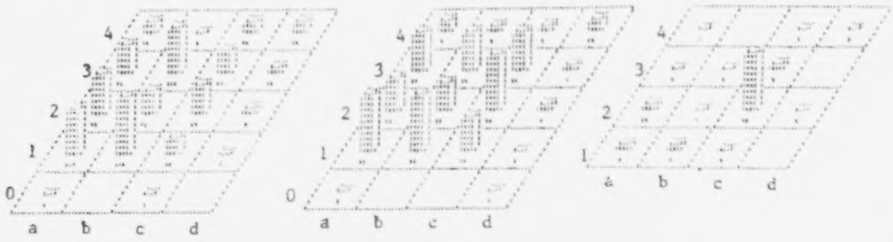
KOREA



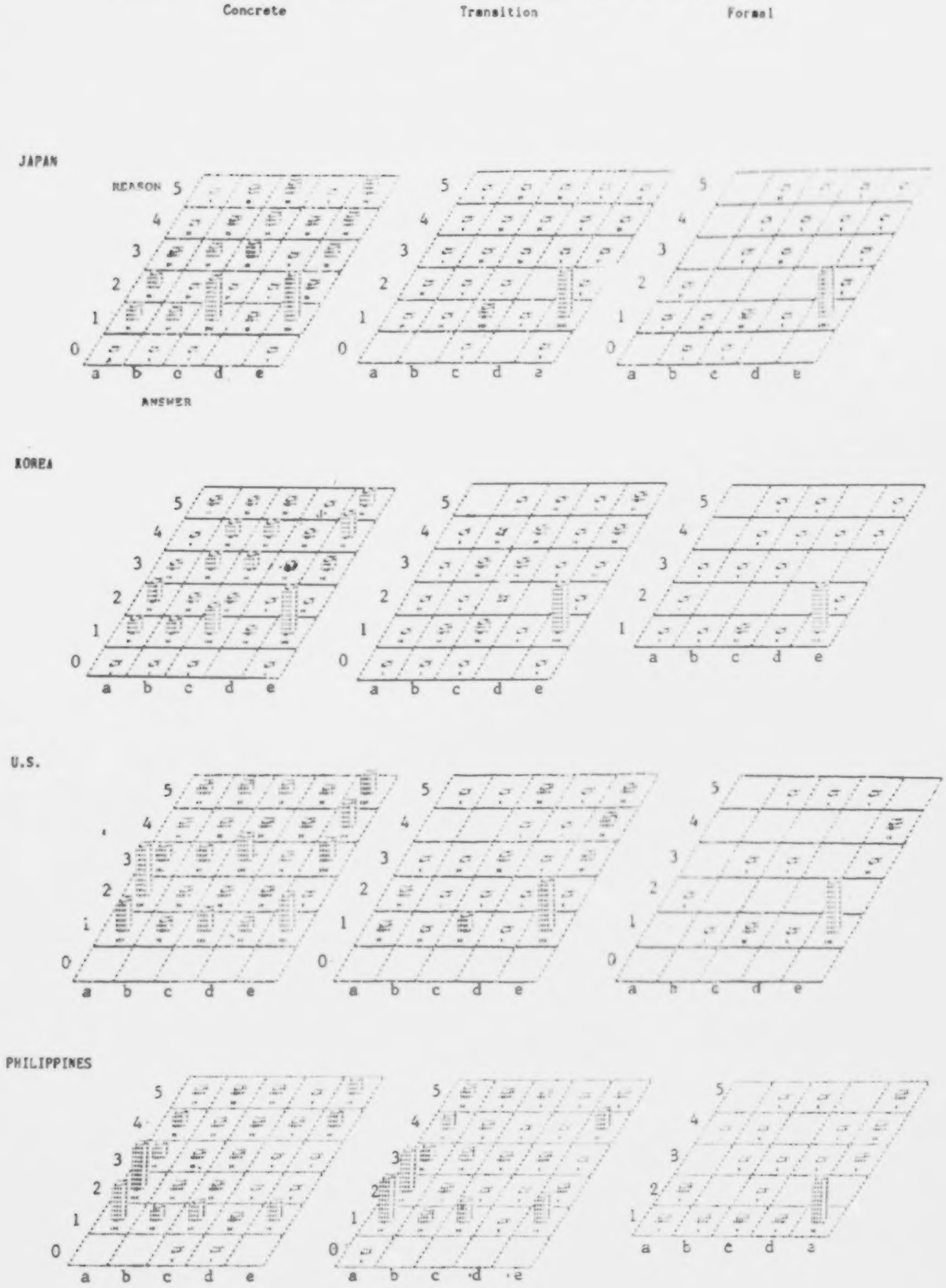
U.S.



PHILIPPINES

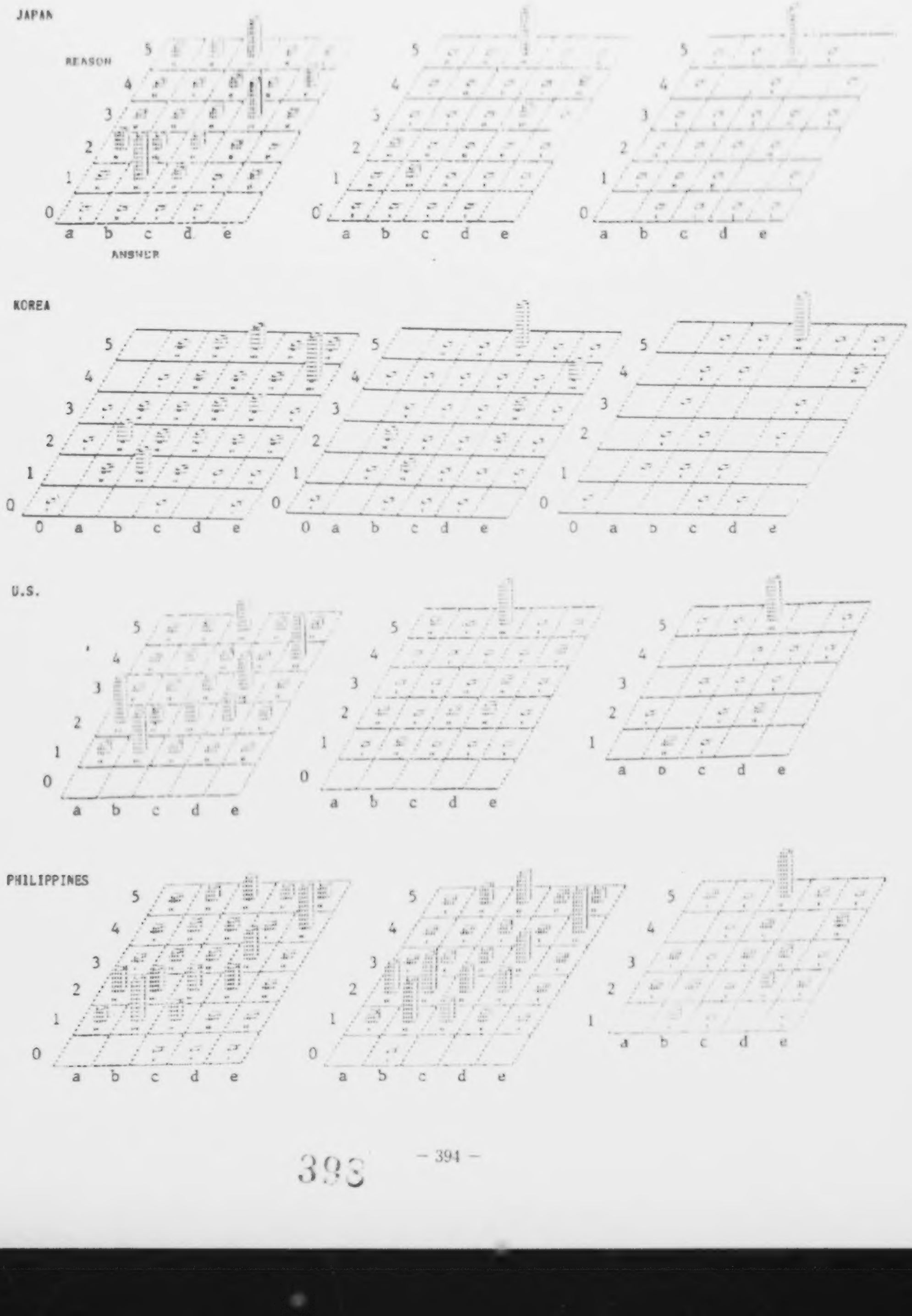


Item4: Proportional Reasoning (Scale#1)



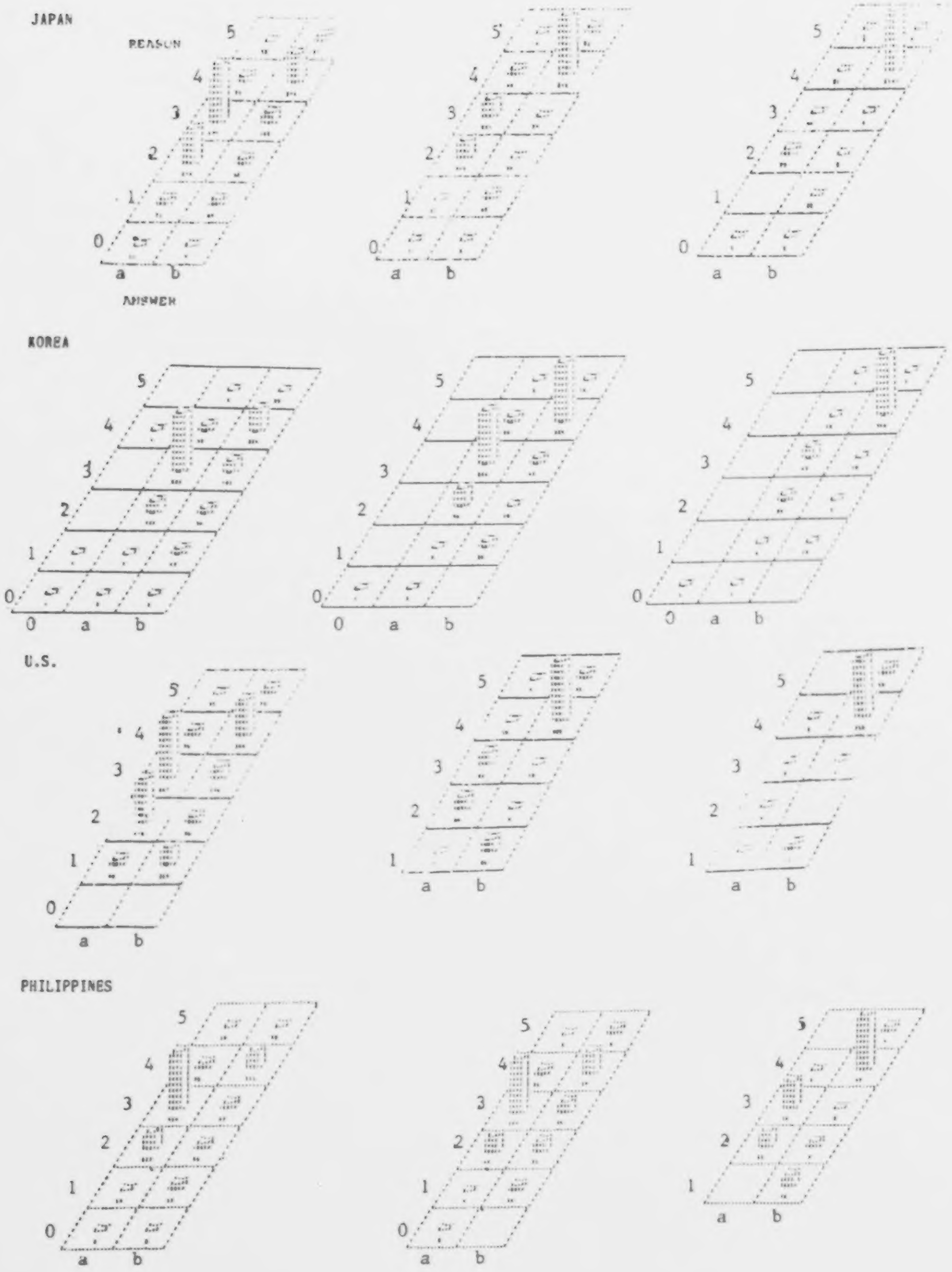
Item5:Controlling Variables (Pendulum Length)

Concrete Transition Formal



Item6:Controlling Variables(Ball#2)

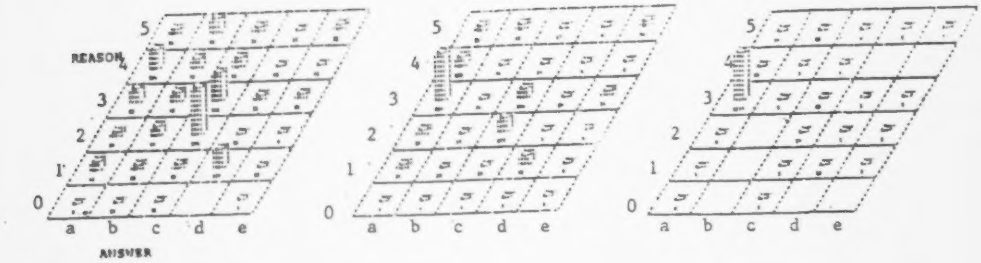
Concrete Transition Formal



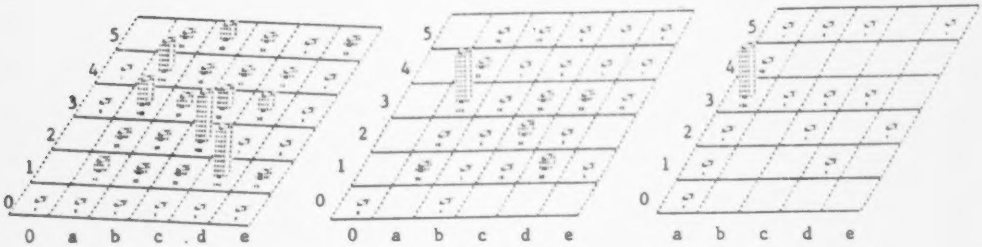
Item7:Probabilistic Reasoning
(Squares & Diamond #1)

Concrete Transition Formal

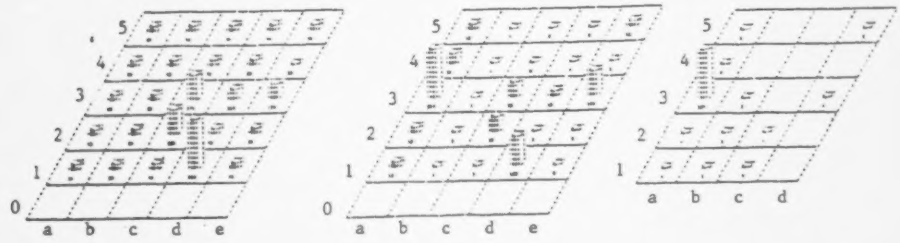
JAPAN



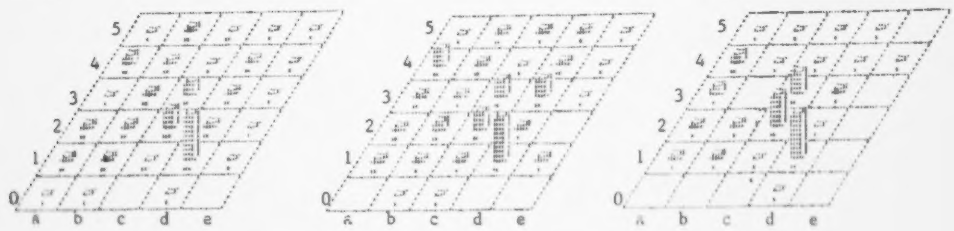
KOREA



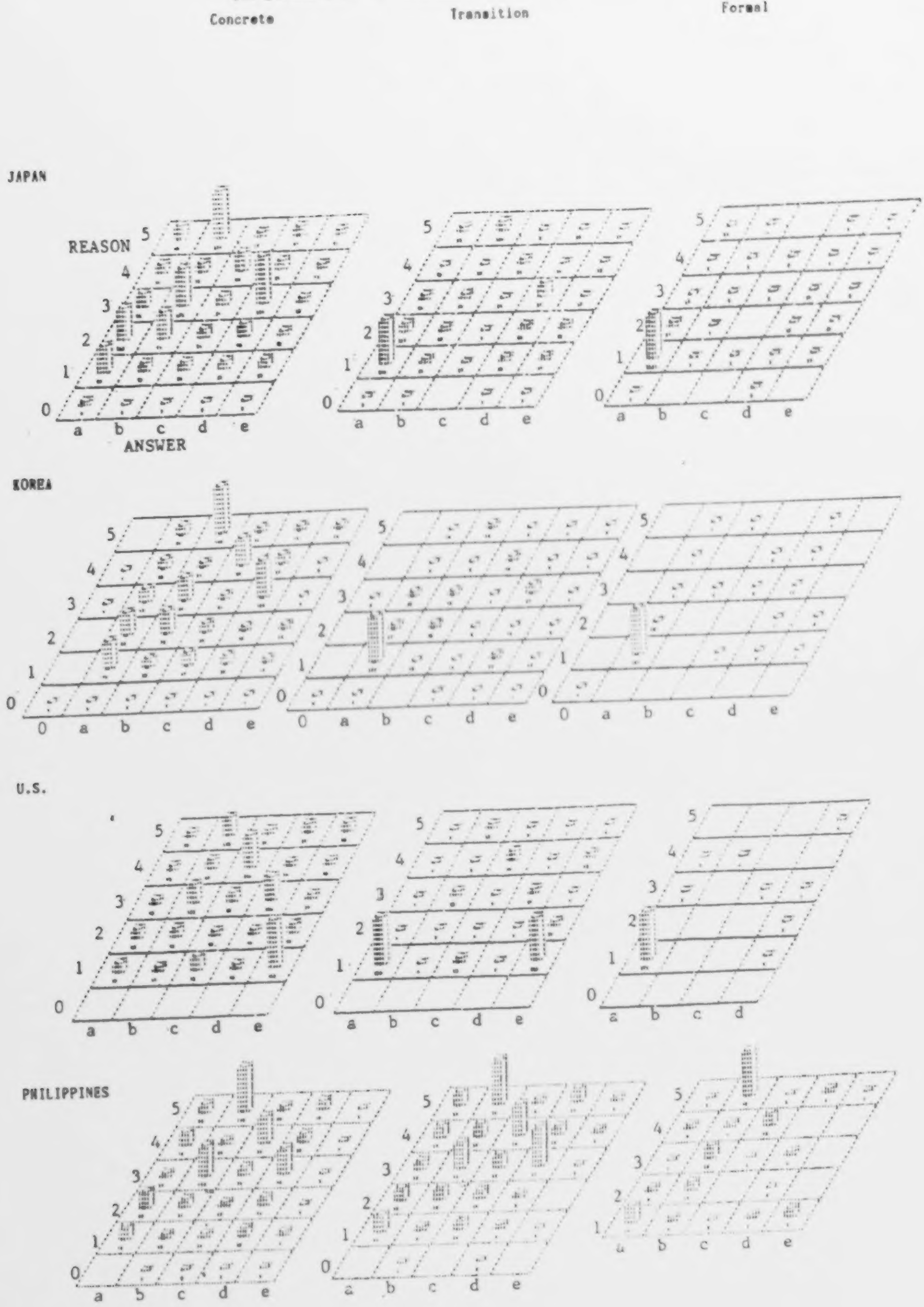
U.S.



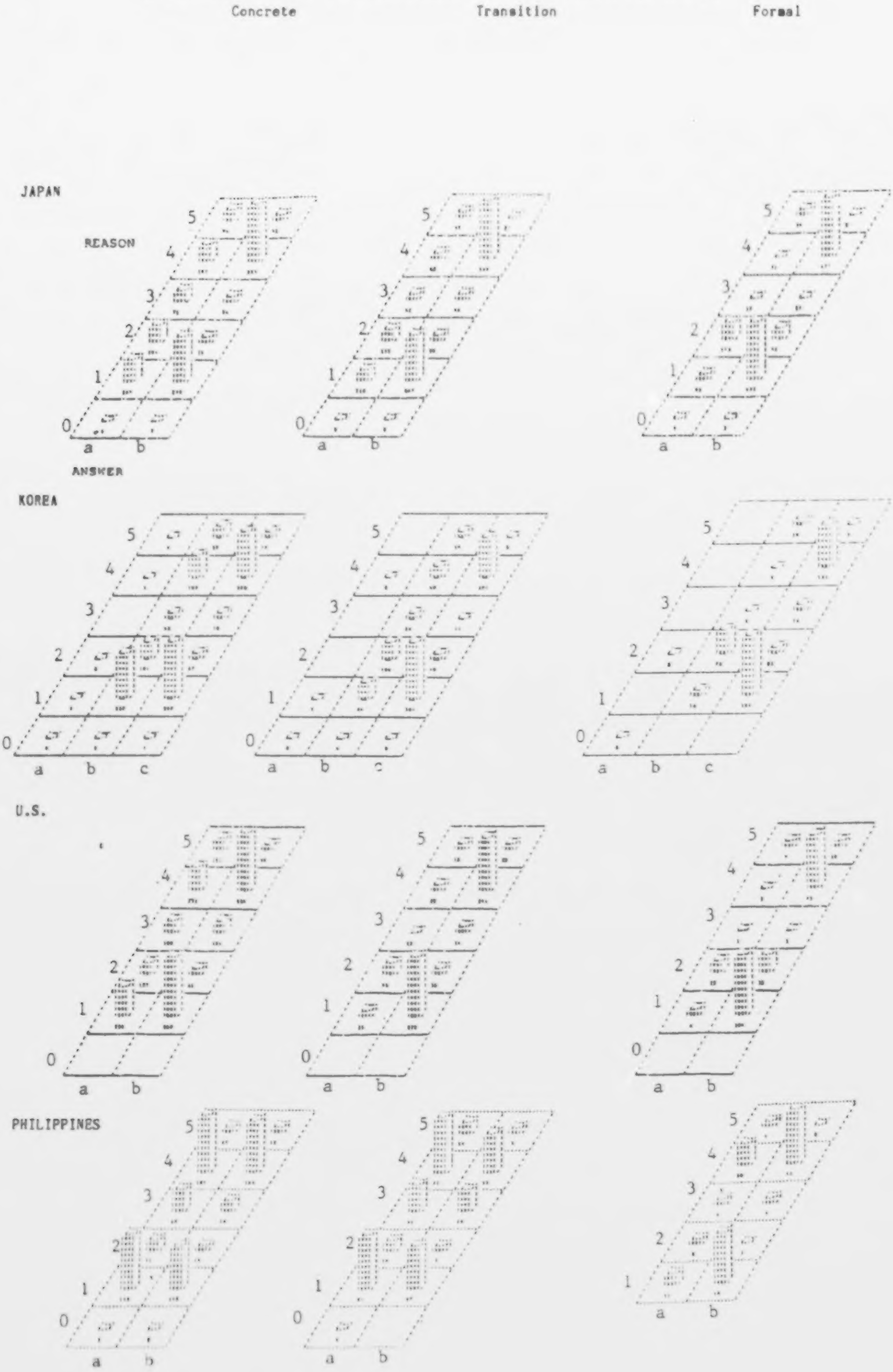
PHILIPPINES



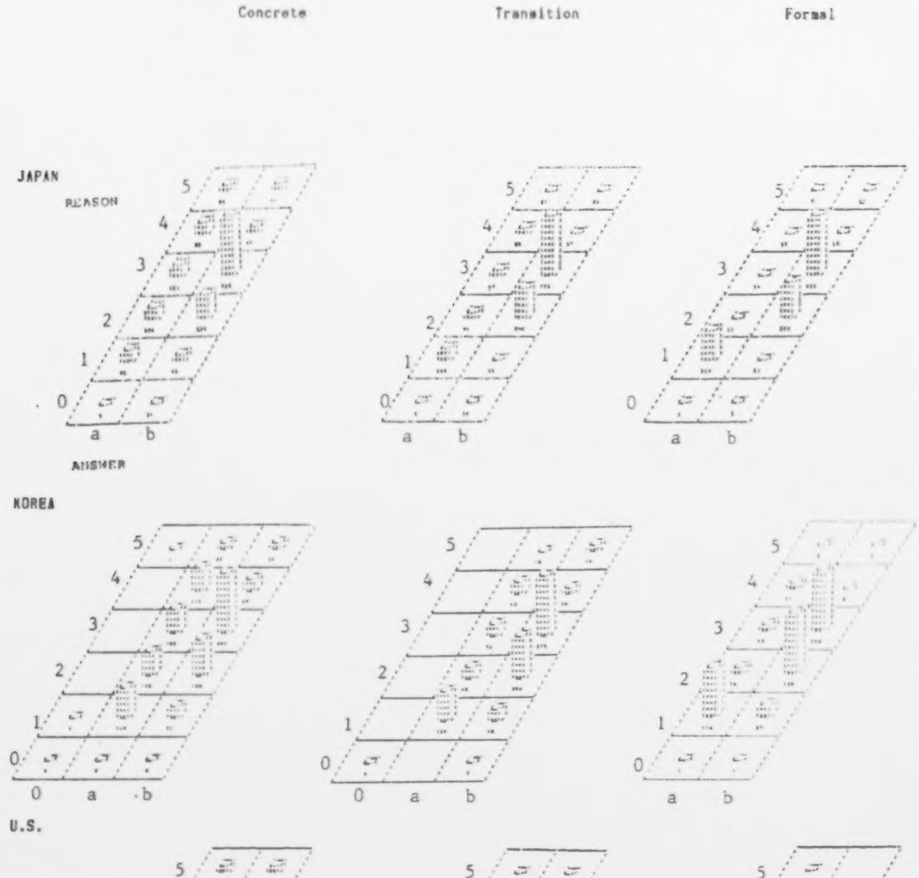
Item8:Probabilistic Reasoning
(Squares & Diamond #2)



Item10:Correlational Reasoning(Mice)



Item9:Correlational Reasoning(Mice)



Appendix 2

ADDITIONAL BASELINE DATA ON THE COGNITIVE SKILLS AND CHARACTERISTICS OF UPPER ELEMENTARY SCHOOL PUPILS

TABLE 73

DEVELOPMENTAL LEVELS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE

	Total Group	By Sex		By Grade	
		MALE	FEMALE	5TH	6TH
Concrete Level (0- 4)	72. 1	70. 4	73. 8	79. 6	64. 6
Transitional Level (5- 7)	22. 6	23. 3	21. 8	18. 4	26. 8
Formal Level (8-12)	5. 3	6. 2	4. 4	2. 1	8. 6

TABLE 74

CORRECT RESPONSES IN PERCENT IN ALL REVISED GALT SUBSCALES
OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY DEVELOPMENTAL LEVEL

	Concrete (0-4)	Transitional (5-7)	Formal (8-12)
G1	54.8	78.2	88.2
G2	8.2	30.7	62.7
G3	19.2	64.9	78.2
G4	2.5	13.4	60.5
G5	8.9	35.5	73.7
G6	32.0	64.9	82.7

TABLE 75

CORRECT RESPONSES IN PERCENT IN ALL POPS SUBSCALE
OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY DEVELOPMENTAL LEVEL

	Concrete (0-4)	Transitional (5-7)	Formal (8-12)
P1	53.6	68.0	76.5
P2	65.6	87.4	92.7
P3	61.2	77.5	85.2
P4	57.9	80.7	92.3
P5	45.4	65.6	71.9
P6	48.2	74.7	85.5

TABLE 76

REVISED GALT SUBSCALES GAIN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE AND DEVELOPMENTAL LEVELS

	by Grade		by Developmental Level		
	Score Gain (5-6)	Pattern 5 6		Score Gain (C-T,T-F)	Pattern C T F
GALT Total	+ 7.1•	↗	C-T	+27.0•	↗
			T-F	+26.4•	
G1 Conservation	+ 5.0•	↗	C-T	+23.4•	↗
			T-F	+10.0•	
G2 Proportional Reasoning	+ 7.6•	↗	C-T	+22.5•	↗
			T-F	+32.0•	
G3 Controlling Variables	+ 8.0•	↗	C-T	+45.7•	↗
			T-F	+13.3•	
G4 Probabilistic Reasoning	+ 5.4•	↗	C-T	+10.9•	↗
			T-F	+47.1•	
G5 Correlational Reasoning	+ 4.4•	↗	C-T	+26.6•	↗
			T-F	+38.2•	
G6 Combinatorial Reasoning	+12.1•	↗	C-T	+32.9•	↗
			T-F	+17.8•	

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TABLE 77

POPS SUBSCALES GAIN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY GRADE AND DEVELOPMENTAL LEVEL

	by Grade		by Developmental Level		
	Score Gain (5-6)	Pattern 5 6	Score Gain (C-T,T-F)		Pattern C T F
POPS Total	• + 4.7	↗	C-T	• +20.5	↗
			T-F	• + 4.0	
P1 Identifying Experimental Questions	NS + 1.0	→	C-T	• +14.4	↗
			T-F	• + 8.5	
P2 Identifying Variables	• + 5.4	↗	C-T	• +21.8	↗
			T-F	• + 5.3	
P3 Formulating Hypothesis	• + 4.4	↗	C-T	• +16.3	↗
			T-F	• + 7.7	
P4 Designing Investigations	• + 6.5	↗	C-T	• +22.8	↗
			T-F	• +11.6	
P5 Graphing Data	• + 6.3	↗	C-T	• +20.2	↗
			T-F	• + 6.3	
P6 Interpreting Data	• + 4.5	↗	C-T	• +26.5	↗
			T-F	• +10.8	

TABLE 78

CORRECT RESPONSES ON EACH POPS SUBSCALE IN PERCENT OF MIDDLE SCHOOL PUPILS IN THE UNITED STATES BY GRADE LEVEL

	Total Group	by Grade		
		6th	7th	8th
POPS Total	46.5	41.5	44.4	55.4
P1	52.7	50.3	49.7	60.0
P2	44.5	38.8	42.0	55.3
P3	59.0	55.0	56.3	67.3
P4	52.3	45.0	51.0	59.3
P5	38.3	33.3	33.7	43.7
P6	36.3	29.7	34.0	47.3

TABLE 79

OUT-OF-SCHOOL SCIENCE EXPERIENCES MEAN IN ALL ITEMS OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Total Group	By Sex		By Grade	
		MALE	FEMALE	5TH	6TH
Total	2.06	2.15	2.02	2.04	2.13
1	2.06	2.12	2.00	1.91	2.21
2	2.17	2.23	2.10	1.97	2.36
3	2.89	2.96	2.83	2.89	2.89
4	2.41	2.38	2.44	2.39	2.43
5	2.77	2.63	2.90	2.77	2.76
6	2.02	1.91	2.14	2.02	2.03
7	2.21	2.23	2.19	2.15	2.27
8	2.80	2.91	2.68	2.76	2.83
9	1.55	1.57	1.52	1.50	1.59
10	1.85	2.10	1.60	1.80	1.90
11	1.99	1.71	2.27	1.98	2.01
12	1.52	1.57	1.48	1.49	1.56
13	1.77	1.82	1.73	1.66	1.88
14	2.38	3.39	1.36	2.30	2.46
15	1.59	1.63	1.55	1.60	1.58
16	1.52	1.59	1.45	1.44	1.60
17	1.69	1.68	1.71	1.63	1.76
18	1.47	1.52	1.42	1.51	1.43
19	1.41	1.43	1.40	1.41	1.42
20	1.25	1.26	1.24	1.26	1.24
21	2.84	2.91	2.76	2.84	2.84
22	1.61	1.71	1.50	1.60	1.61
23	1.67	1.74	1.60	1.66	1.68
24	2.13	2.21	2.06	2.04	2.23
25	2.81	2.63	2.98	2.77	2.85
26	2.37	2.30	2.43	2.42	2.31
27	1.97	2.30	1.65	1.83	2.11
28	3.08	3.54	2.62	2.98	3.19
29	3.23	2.91	3.55	3.22	3.24

TABLE 80

ANALYSIS OF VARIANCE IN THE OUT-OF-SCHOOL SCIENCE EXPERIENCES OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE LEVEL

	Sex Differences (df=1)	Grade Differences (df=1)
Total	28.49••	12.81••
1	8.04••	49.49••
2	9.34••	77.09••
3	5.92•	0.01NS
4	1.65NS	1.13NS
5	32.38••	0.00NS
6	27.29••	0.28NS
7	0.38NS	2.94NS
8	18.56••	1.71NS
9	2.05NS	4.81•
10	114.95••	4.08•
11	157.90••	0.93NS
12	5.24•	2.79NS
13	3.69NS	22.45••
14	1755.08••	5.32•
15	3.70NS	0.36NS
16	13.44••	16.11••
17	0.31NS	11.14••
18	6.60•	5.22•
19	0.69NS	0.11NS
20	0.15NS	0.35NS
21	6.61•	0.02NS
22	21.21••	0.02NS
23	10.46••	0.09NS
24	6.39•	10.06••
25	22.56••	1.30NS
26	3.62NS	2.60NS
27	158.88••	27.83••
28	279.78••	12.26••
29	107.61••	0.44NS

TABLE 81

MOTIVATION TOWARDS SCIENCE PROCESSES MEAN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE

	Total Group	By Sex		By Grade	
		MALE	FEMALE	5TH	6TH
Total	2.82	2.73	2.90	2.73	2.90
1	3.21	3.17	3.25	3.17	3.25
2	2.78	2.70	2.85	2.68	2.87
3	2.93	2.96	2.90	2.90	2.95
4	2.63	2.62	2.64	2.54	2.72
5	2.70	2.68	2.72	2.54	2.86
6	3.01	2.90	3.13	2.94	3.09
7	2.45	2.40	2.51	2.35	2.56
8	2.95	2.87	3.03	2.81	3.09
9	3.19	3.12	3.27	3.16	3.23
10	2.99	2.72	3.26	2.92	3.06
11	2.70	2.52	2.87	2.63	2.77
12	2.50	2.45	2.55	2.37	2.64
13	2.51	2.48	2.54	2.40	2.63
14	2.42	2.38	2.46	2.35	2.50
15	3.38	3.18	3.57	3.27	3.48

TABLE 82

ANALYSIS OF VARIANCE IN THE MOTIVATION TOWARDS SCIENCE PROCESSES OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE LEVEL

	Sex Differences (df=1)	Grade Differences (df=1)
Total	22.13••	22.51••
1	2.65NS	3.25NS
2	10.24••	15.67••
3	1.36NS	0.99NS
4	0.14NS	13.36••
5	0.64NS	30.75••
6	18.41••	8.16••
7	5.02•	17.78••
8	8.26••	25.72••
9	8.88••	2.34NS
10	101.52••	8.70••
11	42.65••	8.22••
12	3.62NS	29.87••
13	1.28NS	21.12••
14	2.74NS	8.74••
15	49.57••	14.72••

TABLE 83

LOVE FOR NATURE MEAN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE

	Total Group	By Sex		By Grade	
		MALE	FEMALE	5TH	6TH
Total	3.72	3.55	3.90	3.63	3.82
1	3.70	3.42	3.98	3.58	3.82
2	3.53	3.43	3.64	3.40	3.66
3	4.05	3.93	4.16	4.00	4.09
4	3.60	3.40	3.80	3.51	4.28

TABLE 84

ANALYSIS OF VARIANCE IN THE LOVE FOR NATURE OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE LEVEL

	Sex Differences (df=1)	Grade Differences (df=1)
Total	73.24••	24.36••
1	138.37••	27.96••
2	15.51••	24.66••
3	20.80••	3.72NS
4	59.46••	15.18••

TABLE 85

ATTITUDE TOWARDS SCIENCE LESSONS MEAN OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE

	Total Group	By Sex		By Grade	
		MALE	FEMALE	5TH	6TH
Total	3.48	3.59	3.38	3.52	3.45
1	3.30	3.32	3.27	3.34	3.26
2	3.60	3.68	3.52	3.62	3.58
3	3.54	3.70	3.38	3.58	3.49
4	3.46	3.60	3.31	3.50	3.41
5	3.09	3.18	3.01	3.13	3.06
6	3.54	3.63	3.46	3.58	3.51
7	3.59	3.65	3.53	3.61	3.57
8	3.67	3.71	3.62	3.66	3.67
9	3.37	3.46	3.29	3.44	3.31
10	3.52	3.63	3.42	3.53	3.52
11	3.51	3.64	3.38	3.52	3.50
12	3.73	3.81	3.65	3.71	3.75
13	3.66	3.72	3.60	3.68	3.64
14	3.48	3.66	3.31	3.56	3.40
15	3.43	3.54	3.32	3.50	3.36
16	3.56	3.61	3.51	3.55	3.57
17	3.75	3.81	3.70	3.75	3.76
18	3.04	3.19	2.88	3.09	2.99
19	3.28	3.40	3.15	3.32	3.23
20	3.30	3.38	3.22	3.33	3.27

TABLE 86

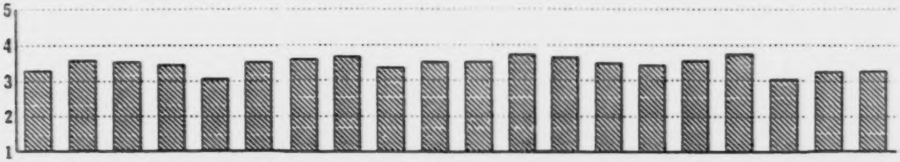
ANALYSIS OF VARIANCE IN THE ATTITUDE TOWARDS SCIENCE LESSONS OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY SEX AND GRADE LEVEL

	Sex Differences (df=1)	Grade Differences (df=1)
Total	31.28••	4.15•
1	1.12NS	2.47NS
2	8.11••	0.53NS
3	35.44••	3.18NS
4	30.28••	2.82NS
5	10.28••	2.30NS
6	11.81••	2.04NS
7	4.58•	0.75NS
8	3.42NS	0.03NS
9	11.23••	5.65•
10	15.92••	0.10NS
11	22.44••	0.24NS
12	9.53••	0.45NS
13	5.62•	0.96NS
14	39.06••	9.39••
15	17.03••	7.22••
16	3.72NS	0.22NS
17	4.04•	0.08NS
18	36.22••	4.45•
19	22.41••	3.36NS
20	7.81••	1.07NS

TABLE 87

MULTIVARIATE ANALYSIS OF VARIANCE AND CORRELATION COEFFICIENT MATRIX IN ALL REVISED GALT AND POPS SUBSCALE AND OUT-OF-SCHOOL SCIENCE EXPERIENCE, MOTIVATION TOWARDS SCIENCE PROCESSES, ATTITUDE TOWARDS SCIENCE LESSONS AND LOVE FOR NATURE OF ELEMENTARY SCHOOL PUPILS IN JAPAN

	Reasoning Skills		Process Skills	
	F	r	F	r
Science Experience Out of School	2.26**	.09***	2.57**	.08***
Motivation toward Science Processes	3.83**	.21***	4.99**	.26***
Love for Nature	6.31**	.14***	9.96**	.23***
Attitude toward Science Lessons	2.69**	.16***	2.78**	.18 ***

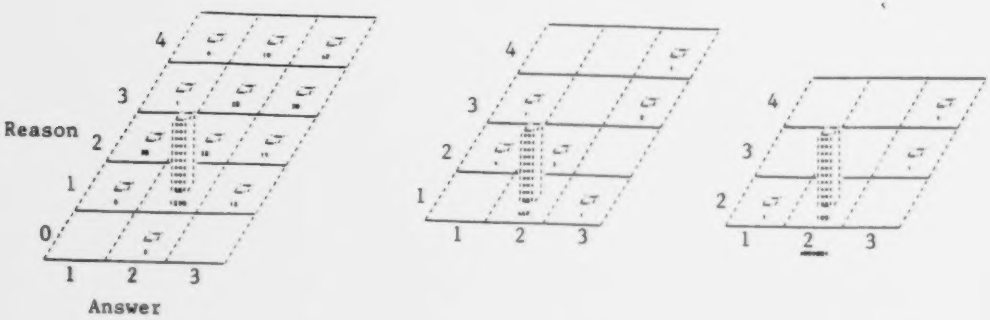


A1	A2	A3	A4	A5	A6	A7	A8	A9	A10	A11	A12	A13	A14	A15	A16	A17	A18	A19	A20
3.30	3.60	3.54	3.46	3.09	3.54	3.59	3.67	3.37	3.52	3.51	3.73	3.66	3.48	3.43	3.56	3.75	3.04	3.28	3.30

FIGURE 88

ATTITUDE TOWARDS SCIENCE LESSONS MEAN
OF ELEMENTARY SCHOOL PUPILS IN JAPAN BY ITEM

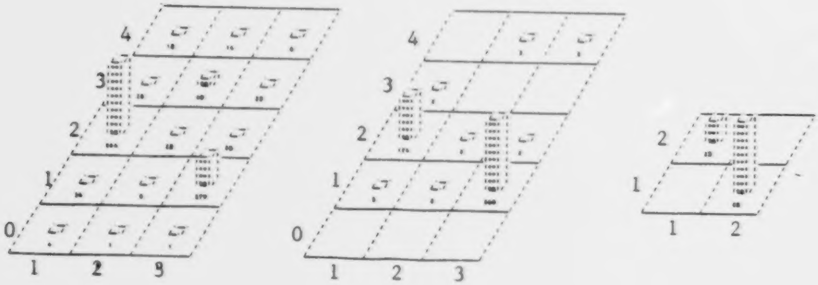
Item 1:Conservation(Piece of Clay)


Concrete

Transition

Formal

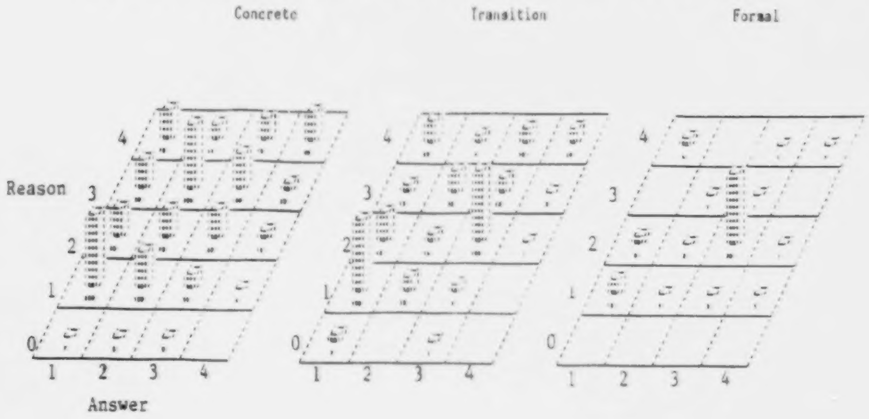
Item 2:Conservation(Metal Weight)


Concrete

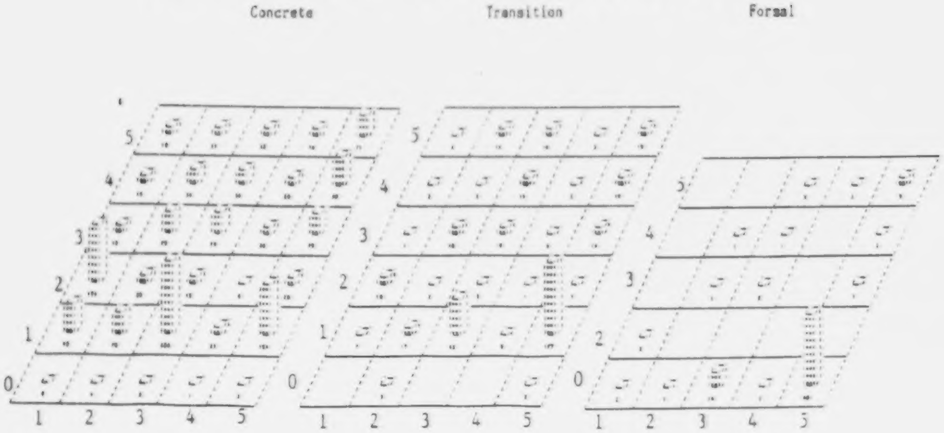
Transition

Formal

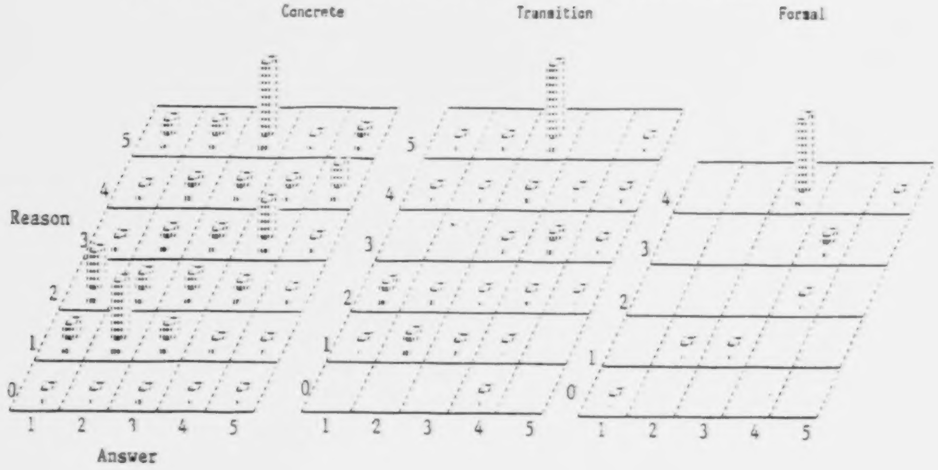
Item3:Proportional Reasoning(Glass Size #2)



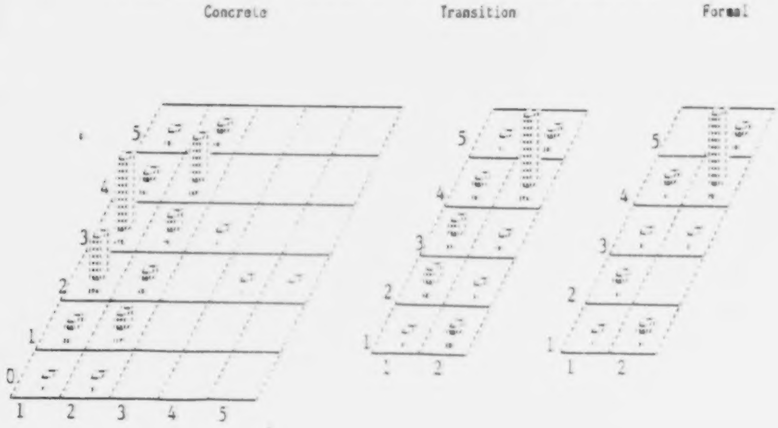
Item4: Proportional Reasoning (Scale#1)



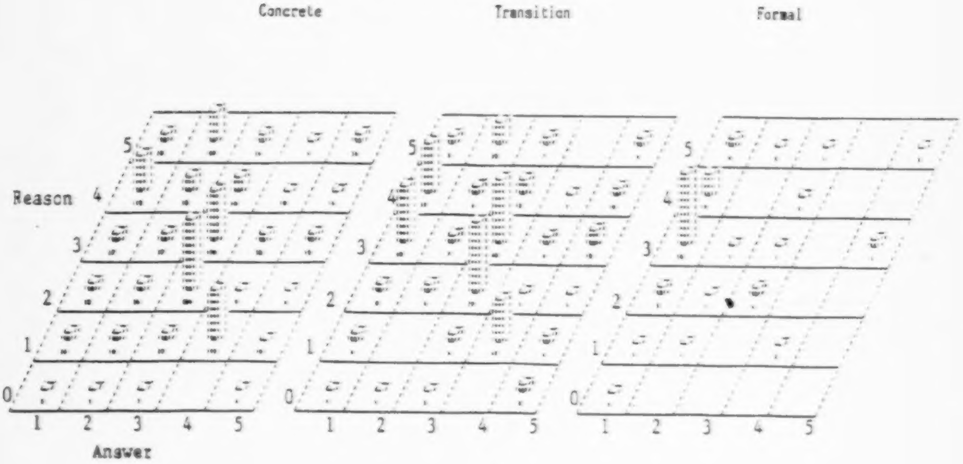
Item5:Controlling Variables (Pendulum Length)



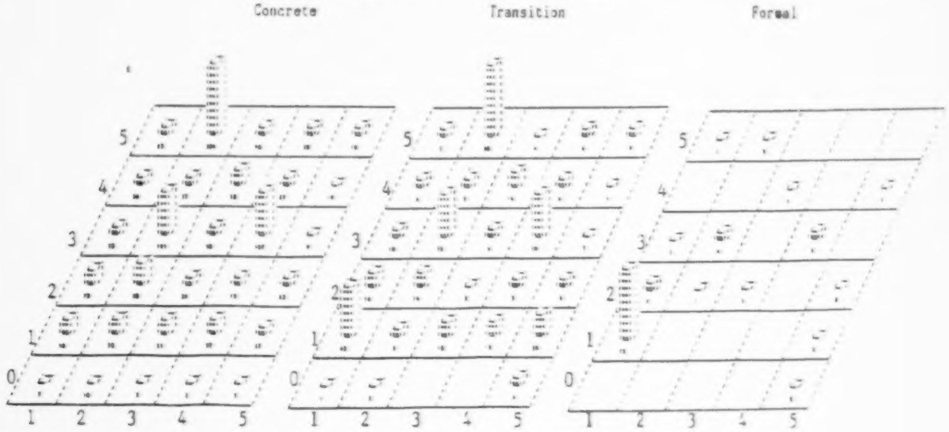
Item6:Controlling Variables(Ball#2)



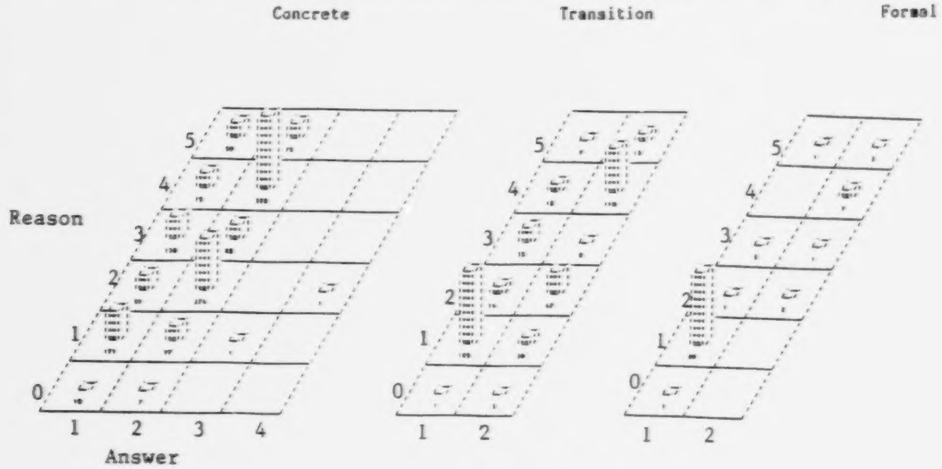
Item7:Probabilistic Reasoning
(Squares & Diamond #1)



Item8:Probabilistic Reasoning
(Squares & Diamond #2)



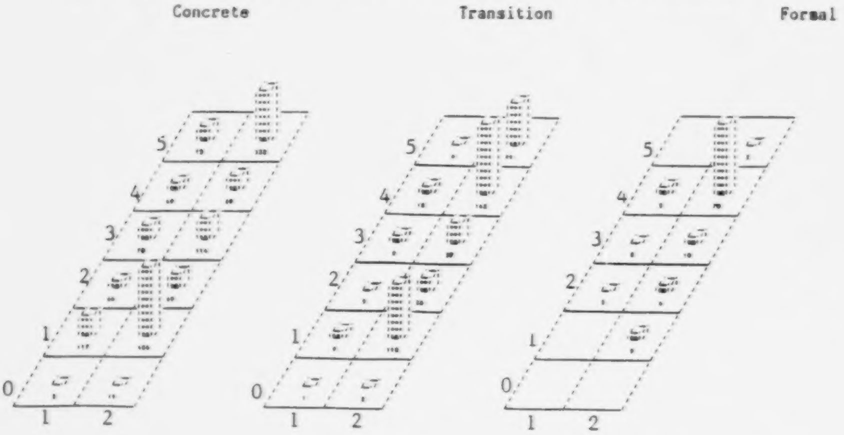
Item9:Correlational Reasoning(Mice)


Concrete

Transition

Formal

Item10:Correlational Reasoning(Mice)


Concrete

Transition

Formal

Apppendix 3

TEST INSTRUMENTS USED IN MEASURING COGNITIVE SKILLS

[GALT]

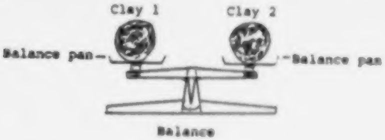
The purpose of this instrument is to learn more about your ability to think logically. Please try to respond to each of the problems by selecting the answer you think is right and then try to select the appropriate reason.

Please make no marks on this test booklet. An answer sheet is provided for you.

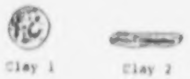
Item 1

Piece of Clay

Tony has two balls of clay. They are the same size and shape. When he places them on the balance, they weigh the same.


Clay 1
Clay 2
Balance pan
Balance pan
Balance

The balls of clay are removed from the balance pans. Clay 2 is flattened like a hotcake.


Clay 1
Clay 2

WHICH OF THESE STATEMENTS IS TRUE?

- a. The hotcake-shaped clay weighs more.
- b. The two pieces weigh the same.
- c. The ball weighs more.

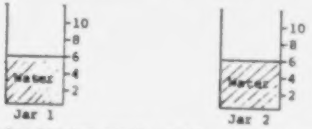
REASON

1. You did not add or take away any clay.
2. When clay 2 was flattened like a hotcake, it had a greater area.
3. When something is flattened, it loses weight.
4. Because of its density, the round ball had more clay in it.

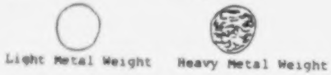
Item 2

Metal Weights

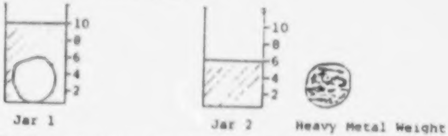
Diana has two jars. They are the same size and shape. Each is filled with the same amount of water.


10
8
6
4
2
Water
Jar 1
10
8
6
4
2
Water
Jar 2

She also has two metal weights of the same volume. One weight is light. The other is heavy.


Light Metal Weight
Heavy Metal Weight

She lowers the light weight into jar 1. The water level in the jar rises and looks like this:


10
8
6
4
2
Jar 1
10
8
6
4
2
Jar 2
Heavy Metal Weight

IF THE HEAVY WEIGHT IS LOWERED INTO JAR 2, WHAT WILL HAPPEN?

- a. The water will rise to a higher level than in jar 1.
- b. The water will rise to a lower level than in jar 1.
- c. The water will rise to the same level as in jar 1.

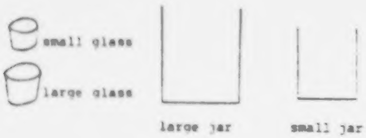
REASON

1. The weights are the same size so they will take up equal amounts of space.
2. The heavier the metal weight, the higher the water will rise.
3. The heavy metal weight has more pressure, therefore the water will rise lower.
4. The heavier the metal weight, the lower the water will rise.

Item 3

Glass Size #2

The drawing shows two glasses, a small one and a large one. It also shows two jars, a small one and a large one.



It takes 15 small glasses of water or 9 large glasses of water to fill the large jar. It takes 10 small glasses of water to fill the small jar. HOW MANY LARGE GLASSES OF WATER DOES IT TAKE TO FILL THE SAME SMALL JAR?

a. 4

b. 5

c. 6

d. other

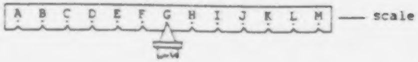
REASON

1. It takes five less small glasses of water to fill the small jar. So it will take five less large glasses of water to fill the same jar.
2. The ratio of small to large glasses will always be 5 to 3.
3. The small glass is half size of the large glass. So it will take about half the number of small glasses of water to fill up the same small jar.
4. There is no way of predicting.

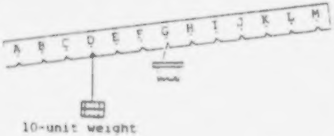
Item 4

Scale #1

Joe has a scale like the one below.



When he hangs a 10-unit weight at point D, the scale looks like this:



WHERE WOULD HE HANG A 5-UNIT WEIGHT TO MAKE THE SCALE BALANCE AGAIN?

a. at point J

b. between K and L

c. at point L

d. between L and M

e. at point M

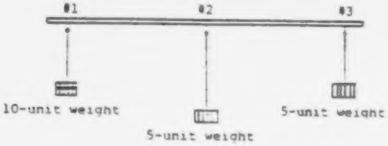
REASON

1. It is half the weight so it should be put at twice the distance.
2. The same distance as 10-unit weight, but in the opposite direction.
3. Hang the 5-unit weight further out, to make up its being smaller.
4. All the way at the end gives more power to make the scale balance.
5. The lighter the weight, the further out it should be hung.

Item 5

Pendulum Length

Three strings are hung from a bar. String #1 and #3 are of equal length. String #2 is longer. Maria attaches a 5-unit weight at the end of string #2 and at the end of #3. A 10-unit weight is attached at the end of string #1. Each string with a weight can be swung.



Maria wants to find out if the length of the string has an effect on the amount of time it takes the string to swing back and forth. WHICH STRING AND WEIGHT WOULD HE USE FOR HIS EXPERIMENT?

a. string #1 and #2
b. string #1 and #3
c. string #2 and #3
d. string #1, #2, and #3
e. string #2 only

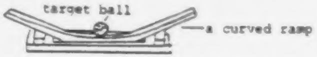
REASON

1. The length of the string should be the same. The weights should be different.
2. Different lengths with different weights should be tested.
3. All strings and their weights should be tested against all others.
4. Only the longest string should be tested. The experiment is concerned with length not weight.
5. Everything needs to be the same except the length so you can tell if length makes a difference.

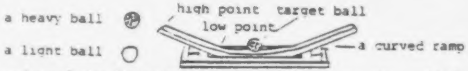
Item 6

Ball #1

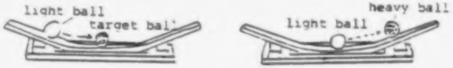
Eddie has a curved ramp. At the bottom of the ramp there is one ball called the target ball.



There are two other balls, a heavy and a light one. He can roll the ball down the ramp and hit the target ball. This causes the target ball to move up the other side of the ramp. He can roll the balls from two different points, a low point and a high point.



Eddie released the light ball from the low point. It rolled down the ramp. It hit and pushed the target ball up the other side of the ramp.



He wants to find out if the point a ball is released from makes a difference in how far the target goes. TO TEST THIS, WHICH BALL WOULD HE NOW RELEASE FROM THE HIGH POINT?

a. the heavy ball
b. the light ball

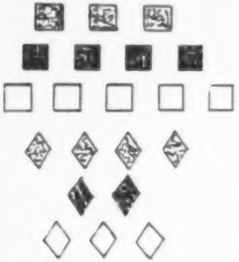
REASON

1. He started with the light ball he should finish with it.
2. He used the light ball the first time. The next time he should use the heavy ball.
3. The heavy ball would have more force to hit the target ball farther.
4. The light ball would have to be released from the high-point in order to make a fair comparison.
5. The same ball must be used as the weight of the ball does not count.

Item 7

Squares and Diamonds #1

In a cloth sack, there are



3 spotted wooden squares

4 black wooden squares

5 white wooden squares

4 spotten wooden diamonds

2 black wooden diamonds

3 white wooden diamonds

All of the square pieces are the same size and shape. The diamond pieces are also the same size and shape. One piece is pulled out of the sack. WHAT ARE THE CHANCES THAT IT IS A SPOTTED PIECE?

a. 1 out of 3
b. 1 out of 4
c. 1 out of 7
d. 1 out of 21
e. other

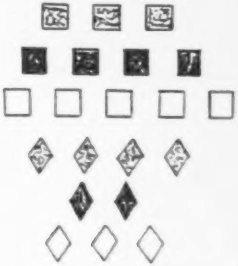
REASON

1. There are twenty-one pieces in the cloth sack. One spotted piece must be chosen from these.
2. One spotted piece needs to be selected from a total of seven spotted pieces.
3. Seven of the twenty-one pieces are spotted pieces.
4. There are three sets in the cloth sack. One of them is spotted.
5. One-fourth of the square pieces and 4/9 of the diamond pieces are spotted.

Item 8

Squares and Diamonds #2

In a cloth sack, there are



3 spotted wooden squares

4 black wooden squares

5 white wooden squares

4 spotten wooden diamonds

2 black wooden diamonds

3 white wooden diamonds

All of the square pieces are the same size and shape. The diamond pieces are also the same size and shape. Reach in and take the first piece you touch. WHAT ARE THE CHANCES OF PULLING OUT A SPOTTED DIAMOND OR A WHITE DIAMOND?

a. 1 out of 3
b. 1 out of 9
c. 1 out of 21
d. 9 out of 21
e. other

REASON

1. Seven of the twenty-one pieces are spotted or white diamonds.
2. 4/7 of the spotted and 3/8 of the white are diamonds.
3. Nine of the twenty-one pieces are diamonds.
4. One diamond piece needs to be selected from a total of twenty-one piece in the cloth sack.
5. There are 9 diamond pieces in the cloth sack. One piece must be chosen from these.

Item 9

The Mice

A farmer observed the mice that live in his field. He found that the mice were either fat or thin. Also, the mice had either black tails or white tails.

This made him wonder if there might be a relation between the size of a mouse and the color of its tail. So he decided to capture all of the mice in one part of his field and observe them. The mice that he captured are shown below.

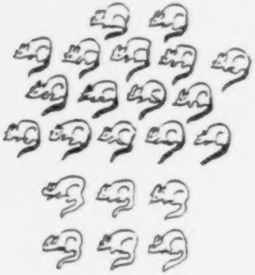
DO YOU THINK THERE IS A RELATION BETWEEN THE SIZE OF THE MICE AND THE COLOR OF THEIR TAILS (THAT IS, IS ONE SIZE OF MOUSE MORE LIKELY TO HAVE A CERTAIN COLOR TAIL AND VICE VERSA)?

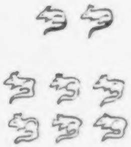
a. Yes

b. No

REASON

1. 8/11 of the fat mice have black tails and 3/4 of the thin mice have white tails.
2. Fat and thin mice can have either a black or a white tail.
3. Not all fat mice have black tails. Not all thin mice have white tails.
4. 18 mice have black tails and 12 have white tails.
5. 22 mice are fat and 8 mice are thin.





Item 10

The Fish

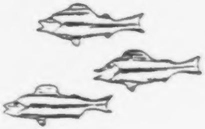
Some of the fish below are big and some are small. Also some of the fish have wide stripes on their sides. Others have narrow stripes. IS THERE A RELATIONSHIP BETWEEN THE SIZE OF THE FISH AND THE KIND OF STRIPES IT HAS (THAT IS, IS ONE SIZE OF FISH MORE LIKELY TO HAVE A CERTAIN TYPE OF STRIPES AND VICE VERSA)?

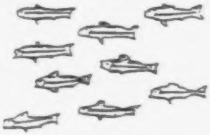
a. Yes

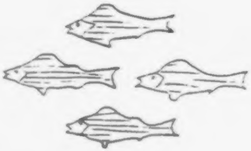
b. No

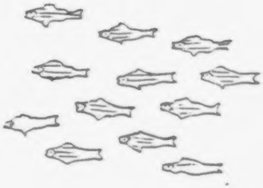
REASON

1. Big and small fish can have either wide or narrow stripes.
2. 3/7 of the big fish and 9/21 of the small fish have wide stripes.
3. 7 fish are big and 21 are small.
4. Not all big fish have wide stripes and not all small fish have narrow stripes.
5. 12/28 of fish have wide stripes and 16/28 of fish have narrow stripes.





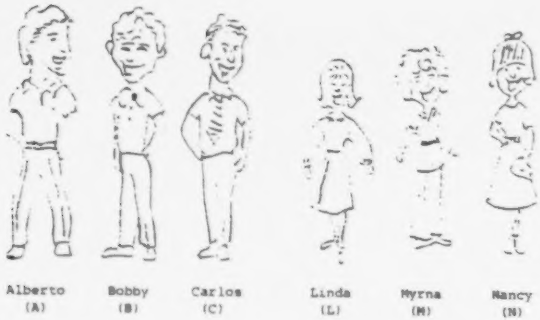




Item 11

The Dance

After supper, some students decide to go dancing. There are three boys: ALBERTO (A), BOBBY (B), and CARLOS (C), and three girls: LINDA (L), MYRNA (M), and NANCY (N).


Alberto
(A)
Bobby
(B)
Carlos
(C)
Linda
(L)
Myrna
(M)
Nancy
(N)

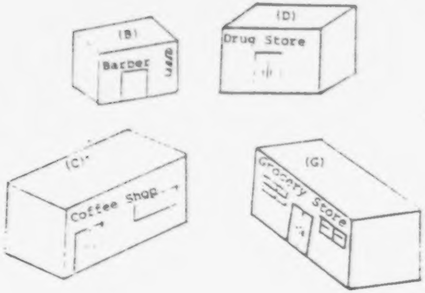
One possible pair of dance partners is A-L, which means ALBERTO AND LINDA.

LIST ALL OTHER POSSIBLE COUPLES OF DANCERS. BOYS DO NOT DANCE WITH BOYS, AND GIRLS DO NOT DANCE WITH GIRLS.

Item 12

The Shopping Center

In a new shopping center, 4 stores are going to be placed on the ground floor. A BARBER SHOP (B), a DRUG STORE (D), a GROCERY STORE (G), and a COFFEE SHOP (C) want to locate there.


(B)
Barber
(D)
Drug Store
(C)
Coffee Shop
(G)
Grocery Store

One possible way that the stores could be arranged in the 4 locations is BDGC. Which means the BARBER SHOP first, the DRUG STORE next, then the GROCERY STORE and the COFFEE SHOP last.

LIST ALL THE OTHER POSSIBLE WAYS THAT THE STORES CAN BE LINED UP IN THE FOUR LOCATIONS.

[TIPS]

The purpose of this instrument is to learn more about your knowledge about the Integrated Process Skills in Science. Please try to respond to each of the problems by selecting your answers from the alternatives listed -- A, B, C and D.

Please make no marks on this test booklet. An answer sheet is provided for you.

1. A softball coach thinks his team loses because his players lack strength. He decides to study factors that influence stregth. Which of the following variables might the coach study to see if it affects the strength of the players?

   A. Amount of vitamins taken each day.

   B. Amount of lifting exercises done each day.

   C. Amount of time spent doing exercises.

   D. All of the above.

2. A study of auto efficiency is done. The hypothesis tested is that a gasoline additive will increase auto efficiency. Five identical cars each receive the same amount of gasoline but with different amounts of Additive A. They travel the same track until they run out of gasoline. The research team records the number of kilometers each car travels. How is auto efficiency measured in this study?

   A. The time each car runs out of gasoline.

   B. The distance each car travels.

   C. The amount of gasoline used.

   D. The amount of Additive A used.

3. An auto manufacturer wants to make cars cheaper to operate. They are studying variables that may affect the number of kilometers per liter that autos get. Which variable is likely to affect the number of kilometers per liter?

   A. Weight of the car.

   B. Size of the motor.

   C. Color of the car.

   D. Both A and B.

4. A class is studying the speed of objects as they fall to the earth. They design an investigation where bags of gravel, weighing different amounts will be dropped from the same height. In their investigation which of the following is the hypothesis they would test about the speed of objects falling to earth?

   A. An object will fall faster when it is dropped further.

   B. The higher an object is in the air the faster it will fall.

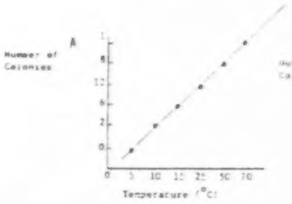
   C. The larger the pieces of gravel in a bag the faster it will fall.

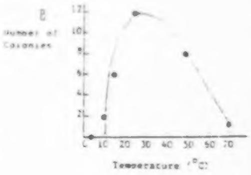
   D. The heavier an object the faster it will fall to the ground.

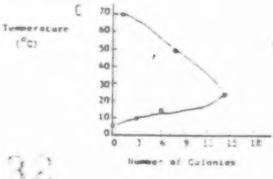
5. A student in a science class studied the effect of temperature on the growth of bacteria. The student obtained the following data:

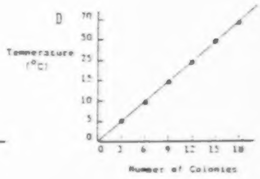
Temperature of growth chamber (°C)	Number of bacterial colonies
5	0
10	2
15	6
25	12
50	8
70	1

Which graph correctly represents the data from the experiment?









6. A police chief is concerned about reducing the speed of autos. He thinks several factors may affect automobile speed. Which of the following is a hypothesis he could test about how fast people drive?

A. The younger the drivers, the faster they are likely to drive.

B. The larger the autos involved in an accident, the less likely people are to get hurt.

C. The more policemen on patrol, the fewer the number of auto accidents.

D. The older the autos, the more accidents they are likely to be in.

7. The effect of wheel width on ease of rolling is being studied by a science class. The class puts wide wheels onto a small cart and lets it roll down an inclined ramp and then across the floor. The investigation is repeated using the same cart but this time fitted with narrow wheels. How could the class measure ease of rolling?

A. Measure the total distance the cart travels.

B. Measure the angle of the inclined ramp.

C. Measure the width of each of the two sets of wheels.

D. Measure the weight of each of the carts.

8. A farmer wonders how he can increase the amount of corn he grows. He plans to study factors that affect the amount of corn produced. Which of these hypotheses could he test?

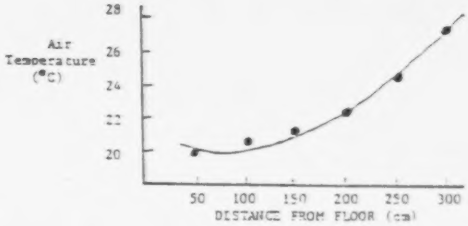
A. The greater the amount of fertilizer the larger the amount of corn produced.

B. The greater the amount of corn, the larger the profits for the year.

C. As the amount of rainfall increases, the more effective the fertilizer.

D. As the amount of corn produced increases, the cost of production increases.

9. A study is done of the temperature in a room at different distances above the floor. The graph of the data is shown below. How are the variables related?



A. As distance from the floor increases, air temperature decreases.

B. As distance from the floor increases, air temperature increases.

C. An increase in air temperature means a decrease in distance from the floor.

D. The distance from the floor is not related to air temperature increases.

10. Juan thinks that the more air pressure in a basketball, the higher it will bounce. To investigate this hypothesis he collects several basketballs and an air pump with a pressure guage. How should Juan test his hypothesis?

A. Bounce basketballs with different amounts of force from the same height.

B. Bounce basketballs having different air pressures from the same height.

C. Bounce basketballs having the same air pressure at different angles from the floor.

D. Bounce basketballs having the same amount of air pressure from different heights.

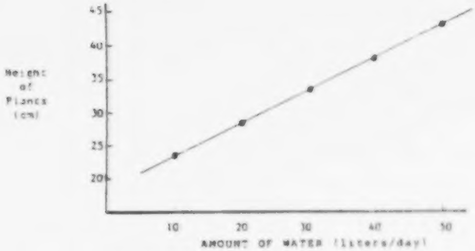
11. A study is being done on the amount of water needed to grow plants. Five small plots are given different amounts of water. After two months the height of the plants is measured. The data are shown in the graph. What is the relationship between the variables?

A. Increasing the amount of water increases the height of the plants.

B. Increasing the height of the plants increases the amount of water.

C. Decreasing the amount of water increases the height of the plants.

D. Decreasing the height of the plants decreases the amount of water.



12. Jose wanted to find out if the temperature of water affected the amount of sugar that would dissolve in it. He put 50ml. of water into each of four identical jars. He changed the temperatures of the jars of water until he had one at 0 °C, one at 50 °C, and one at 75 °C, and one at 95 °C. He then dissolved as much sugar as he could in each jar by stirring.

What is the hypothesis being tested?

A. The greater the amount of stirring, the greater the amount of sugar dissolved.

B. The greater the amount of sugar dissolved, the sweeter the liquid.

C. The higher the temperature, the greater the amount of sugar dissolved.

D. The greater the amount of water used, the higher the temperature.

13. What is a controlled variable in this study?

A. Amount of sugar dissolved in each jar.

B. Amount of water placed in each jar.

C. Number of jars used to hold water.

D. The temperature of the water.

14. What is the dependent or responding variable?

A. Amount of sugar dissolved in each jar.

B. Amount of water placed in each jar.

C. Number of jars used to hold water.

D. The temperature of the water.

15. What is the independent or manipulated variable?

A. Amount of sugar dissolved in each jar.

B. Amount of water placed in each jar.

C. Number of jars used to hold water.

D. The temperature of the water.

16. Susan is studying food production in bean plants. She measures food production by the amount of starch produced. She notes that she can change the amount of light, the amount of carbon dioxide, and the amount of water that plants receive. What is a testable hypothesis that Susan could study in this investigation?

A. The more carbon dioxide a bean plant gets the more starch it produces.

B. The more starch a bean plant produces the more light it needs.

C. The more water a bean plant gets the more carbon dioxide it needs.

D. The more light a bean plant receives the more carbon dioxide it will produce.

17. Marie wondered if the earth and oceans are heated equally by sunlight. She decided to conduct an investigation. She filled a bucket with dirt and another bucket of the same size with water. She placed them so each bucket recieved the same amount of sunlight. The temperature in each was measured every hour from 8:00 a.m. to 6:00 p.m.

Which hypothesis was being tested?

A. The greater the amount of sunlight, the warmer the soil and water become.

B. The longer the soil and water are in the sun, the warmer they become.

C. Different types of material are warmed differently by the sun.

D. Different amounts of sunlight are received at different times of the day.

18. Which of these variables is controlled in the study?

A. Kind of water placed in the bucket.

B. Temperature of the water and soil.

C. Type of material placed in the buckets.

D. Amount of time each bucket is in the sun.

19. What was the dependent or responding variable?

A. Kind of water placed in the bucket.

B. Temperature of the water and soil.

C. Type of material placed in the buckets.

D. Amount of time each bucket is in the sun.

20. What was the independent or manipulative variable?

A. Kind of water placed in the bucket.

B. Temperature of the water and soil.

C. Type of material placed in the bucket.

D. Amount of time each bucket is in the sun.

21. A greenhouse manager wants to speed up the production of tomato plants to meet the demands of anxious gardeners. She plants tomato seeds in several trays. Her hypothesis is that the more moisture seeds receive the faster they sprout? How can she test this typothesis?

A. Count the number of days it takes seeds receiving different amounts of water to sprout.

B. Measure the height of the tomato plants a day after each watering.

C. Measure the amount of water used by plants in different trays.

D. Count the number of tomato seeds placed in each of the trays.

22. A gardener notices that his squash plants are being attacked by aphids. He needs to get rid of the aphids. His brother tells him that "Aphid-Away" powder is the best insecticide to use. The town agent says "Squash-Saver" spray works best. The gardener selects six squash plants and applies the powder to three and the spray to three. A week later he counts the number of live aphids on each of the plants. How is the effectiveness of the insecticides measured in this study?

A. Measuring the amount of spray and powder used.

B. Determining the condition of the plants after spraying or dusting.

C. Weighing the squash each plant produces.

D. Counting the number of aphids remaining on the plants.

23. Lisa wants to measure the amount of heat energy a flame will produce in a certain amount of time. A burner will be used to heat a beaker containing a liter of cold water for ten minutes. How will Lisa measure the amount of heat energy produced by the flame?

A. Note the change in water temperature after ten minutes.

B. Measure the volume of water after ten minutes.

C. Measure the temperature of the flame after ten minutes.

D. Calculate the time it takes for the liter of water to boil.

24. Manuel is studying the effect of temperature on the rate that oil flows. His hypothesis is that as the temperature of the oil increases it flows faster. How could he test this hypothesis?

A. Heat oil to different temperatures and weigh it after it flows out of the can.

B. Observe the speed at which oil at different temperatures flows down a smooth surface.

C. Let oil flow down smooth surfaces at different angles and observe its speed.

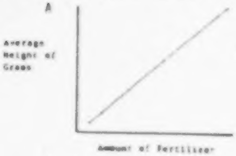
D. Measure the time it takes for oil of different thickness to pour out of the can.

25. A researcher is testing a new fertilizer. Five small fields of the same size are used. Each field receives a different amount of fertilizer. One month later the average height of the grass in each plot is measured. The measurements are shown in the table below.

Amount of Fertilizer (kg)	Average Height of Grass (cm)
10	7
30	10
50	12
80	14
100	12

Which graph represents the data in the table?

A



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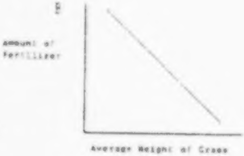

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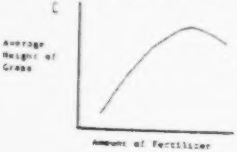

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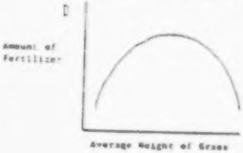


26. A biologist tests his hypothesis: the greater the amount of vitamins given to rats the faster they will grow. How can the biologist measure how fast rats will grow?

A. Measure the speed of the rats.

B. Measure the amount of exercises the rats receive.

C. Weigh the rats every day.

D. Weigh the amount of vitamins the rats will eat.

27. Some students are considering variables that might affect the time it takes for sugar to dissolve in water. They identify the temperature of the water, the amount of sugar and the amount of water as variables to consider. What is the hypothesis the students could test about the time it takes for sugar to dissolve in water?

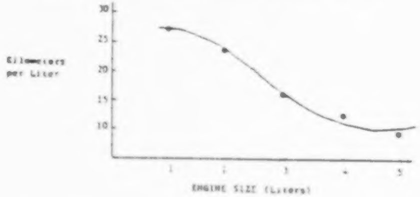
A. The larger the amount of sugar the more water required to dissolve it.

B. The colder the water the faster it has to be stirred to dissolve.

C. The warmer the water the more sugar that will disolve.

D. The warmer the water the more time it takes the sugar to dissolve.

28. A consumer group measures the kilometers per liter cars get with different size engines. The results are as follows:



Which of the following describes the relationship between the variables?

A. The larger the engine the more kilometers per liter the car gets.

B. The fewer kilometers per liter the car gets the smaller the engine.

C. The smaller the engine the more kilometers per liter a car gets.

D. The more miles per liter for a car the larger the engine.

29. A study was done to see if leaves added to soil had an effect on tomato production. Tomato plants were grown in four large tubs. Each tub had the same kind and amount of soil. One tub had 15 kg of rotted leaves mixed in the soil and a second had 10 kg. A third tub had 5 kg and the fourth had no leaves added. Each tub was kept in the sun and watered the same amount. The number of kilograms of tomatoes produced in each tub was recorded.

What is the hypothesis being tested?

A. The greater the amount of sunshine, the greater the amount of tomatoes produced.

B. The larger the tub, the greater the amount of leaves added.

C. The greater the amount of water added, the faster the leaves rotted in the tubs.

D. The greater the amount of leaves added, the greater the amount of tomatoes produced.

30. What is a controlled variable in this study?

A. Amount of tomatoes produced in each tub.

B. Amount of leaves added to the tubs.

C. Amount of soil in each tub.

D. Number of tubs receiving rotted leaves.

31. What is the dependent or responding variable?

A. Amount of tomatoes produced in each tub.

B. Amount of leaves added to the tubs.

C. Amount of soil in each tub.

D. Number of tubs receiving rotted leaves.

32. What is the independent or manipulated variable?

A. Amount of tomatoes produced in each tub.

B. Amount of leaves added to the tubs.

C. Amount of soil in each tub.

D. Number of tubs receiving rotted leaves.

33. A student is investigating the lifting ability of magnets. He has several magnets of different sizes and shapes. For each magnet, the student weighs the amount of iron filings it picks up. How is the lifting ability of a magnet defined in the experiment?

A. The size of the magnet in use.

B. The weight of the magnet picking up things.

C. The shape of the magnet in use.

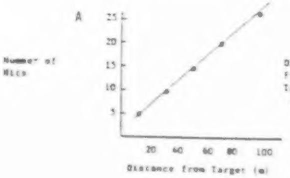
D. The weight of the iron filings picked up.

34. Twenty-five shots are fired at a target from several distances. The table below shows the number of "hits" in 25 shots at each distance.

Distance from Target (m)	Number of Hits
5	25
15	10
25	10
50	5
100	2

Which graph best represents the data?

A



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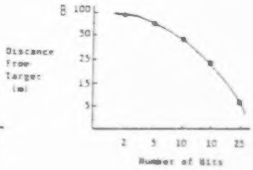
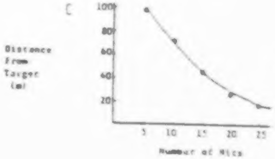


C



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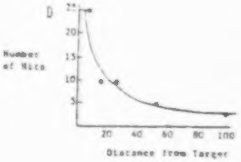

35. Luz has an aquarium in which she keeps goldfish. She notices that the fish are very active sometimes but not at others. She wonders what affects the activity of the fish. What is a hypothesis she could test about factors that affect the activity of the fish?

A. The more you feed fish, the larger the fish become.

B. The more active the fish, the more food they need.

C. The more oxygen in the water, the larger the fish become.

D. The more light on the acquarium, the more active the fish.

36. Mr. Manuel has an all electric house and is concerned about his electric bill. He decides to study factors that affect how much electrical energy he uses. Which variable might influence the amount of electrical energy used?

A. The amount of television the family watches.

B. The location of the electric meter.

C. The number of baths taken by family members.

D. A and C.

PERFORMANCE OF PROCESS SKILLS TEST

(POPS)

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Adapted from

MIDDLE GRADES INTEGRATED SCIENCE PROCESS SKILLS TEST
(MIPT)

by

Dr. Michael J. Padilla (University of Georgia)

Dr. Linda L. Cronin (University of Florida)

September, 1987

Performance of Process Skills (POPS)

Questions 1-4 refer to the following situation:

Sarah wanted to find out if heat has an effect on the growth of mold. She grew the mold in nine jars with the same amount and type of food. Three jars were kept at 0°C. Three were kept at 90°C. Three were kept at 27°C. The growth of the mold was recorded after four days.

1. What is the hypothesis that she is testing?

   a. The type of food will affect the amount of mold.
   b. The amount of mold is affected by the temperature.
   c. The amount of mold is affected by the amount of food used.
   d. The number of jars affects the amount of mold.

2. What is the controlled variable or condition that was kept constant?

   a. temperature of the jar
   b. type of jar used
   c. temperature of the mold
   d. amount of food

3. What is the responding variable or the condition which is the measured outcome of the experiment?

   a. growth of mold
   b. amount of food in each jar
   c. temperature of the jar
   d. number of jars at each temperature

4. What is the manipulated variable or the condition which was changed?

   a. temperature of the jars
   b. amount of food in each jar
   c. growth of mold
   d. number of jars at each temperature

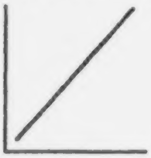
5. Mark is studying how heat affects how fast oil flows. He guesses that as the oil gets hotter, it flows faster. How could he test this?

   a. Heat oil to different temperatures. Then weigh it after it flows out of the can.
   b. Observe how fast oil at different temperatures flows down a smooth surface.
   c. Let oil flow down smooth surfaces at different angles. Observe its speed.
   d. Measure the time it takes for oil of different thicknesses to pour out of the can.

6. A science class was studying pressure and volume with balloons. The did an experiment. They changed the pressure on a balloon. They then measured its volume. The results are given in the table.

Pressure on balloon (N/cm^2)	Volume of balloon (ml)
0.35	980
0.70	400
1.03	320
1.40	220
1.72	180

Which one of the graphs shows the data correctly?

A


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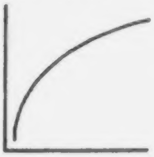

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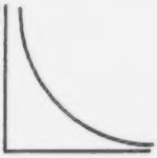

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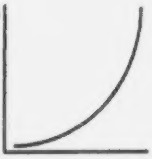
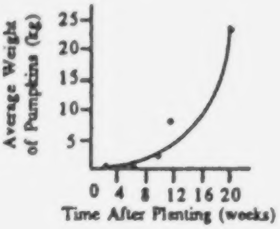


7. Eddie grew pumpkins. He found the average weight of ten pumpkins at different times after planting. His results are listed below.

Time After Planting (weeks)	Average Weight of Pumpkins (kg)
2	0
7	0
9	1
12	9
18	22

Which one of these graphs *best* describes his results?

A


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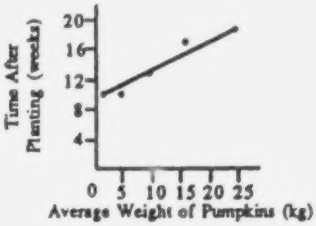
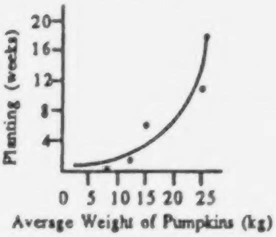
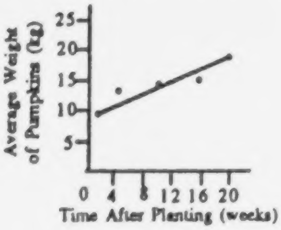


C


D


8. A gardener wants to grow better bean plants. She plants bean seeds in many trays. Her hypothesis is that the more moisture seeds receive, the faster they sprout. How can she test this?

   a. Count the time it takes seeds to sprout which receive different amounts of water.
   b. Measure the height of the bean plants a day after each watering.
   c. Measure the amount of water used by beans in different trays.
   d. Count the number of bean seeds placed in each of the trays.

9. Dan wants to experiment with cockroaches. Which one of the following questions about cockroaches is the *best* for testing in an experiment?

   a. Does temperature affect cockroach activity?
   b. Why do cockroaches come out at night?
   c. How do cockroaches move about so fast?
   d. Why are cockroaches so old?

10. Jim thinks that the more air pressure in a ball, the higher it will bounce. He collects some balls and an air pump with a pressure gauge. How should Jim test this?

   a. Bounce balls with different amounts of force from the same height.
   b. Bounce balls having different air pressures from the same height.
   c. Bounce balls having the same air pressure at different angles from the floor.
   d. Bounce balls having the same amount of air pressure from different heights.

Questions 11-14 refer to the following situation:

A fire destroyed a large forest. The forest rangers want to test how different types of grasses affect soil erosion. They choose ten plots of ground that are the same size. These plots receive the same amount of sun. They also have the same kind of soil. The rangers plant each plot with a different type of grass. Measurements of soil erosion are made every week for the entire summer.

11. What is the manipulated variable or the condition which was changed?

   a. the size of the plots
   b. the types of grasses
   c. the amount of soil erosion
   d. the type of soil in the plots

12. What is the responding variable or the condition which is the measured outcome of the experiment?

   a. the size of the plots
   b. the types of grasses
   c. the amount of soil erosion
   d. the type of soil in the plots

13. What hypothesis is being tested in this study?

   a. Some types of grass reduce soil erosion more than others.
   b. Soil erosion is affected by the slope of the land.
   c. Burned-over areas have greater erosion than forested areas.
   d. Planting grass will reduce the amount of soil erosion.

14. Which one of the following variables is NOT controlled in this study?

   a. the size of the plots
   b. the type of soil in the plots
   c. the amount of soil erosion
   d. the amount of sun the plots receive

15. Tom wants to test the effectiveness of dishwashing liquids. Which one of the following questions about dishwashing liquids is the *best* for testing in an experiment?

   a. What color are the dishwashing liquids?
   b. Which dishwashing liquid is better?
   c. Which dishwashing liquid washes dishes better?
   d. Which dishwashing liquid is oldest?

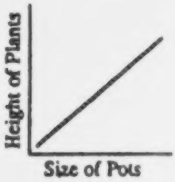
16. Nancy has been playing with a water rocket. She can change the amount of water and the angle of release of the rocket. She can also change the weight of the rocket.

   Which one of the following is a hypothesis she could test about these variables?

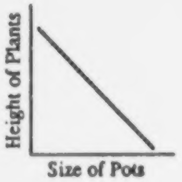
   a. Rockets with warm water will rise higher than rockets with cold water.
   b. Rockets with four tail fins will rise higher than rockets with two tail fins.
   c. Rockets with pointed nose cones will rise higher than rockets with rounded nose cones.
   d. Rockets with more water will rise higher than rockets with less water.

Use the following information to answer questions 17 and 18:

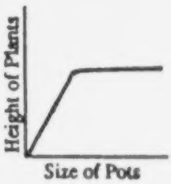
Dick plans to study how well plants grow in different size pots. The graphs below show four possible outcomes of his experiment.



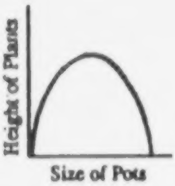
A



B



C



D

17. Which graph shows that as the pot size increases, the plant height decreases?

18. Which graph shows that as the pot size increases, the plant height increases up to a certain pot size but with larger pots, plant height remains the same?

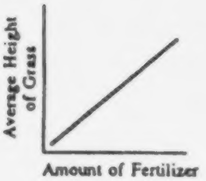
19. Some students want to do an experiment. Which one of the following questions is the *best* for testing in an experiment?

   a. Why do magnets work?
   b. Why do plants grow most during the summer?
   c. What factors affect plant growth during the year?
   d. What is the affect of different amounts of water on plant growth?

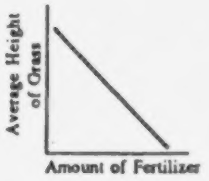
20. Don tested a new fertilizer. He used five small fields of the same size. Each field received a different amount of fertilizer. He measured the average height of the grass in each field one month later. Here are his results.

Amount of Fertilizer (kg)	Average Height of Grass (cm)
10	7
30	10
50	12
70	14
90	12

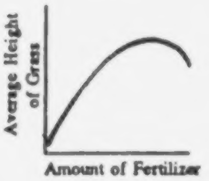
Which graph *best* represents the data in the table?



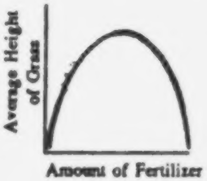
A



B

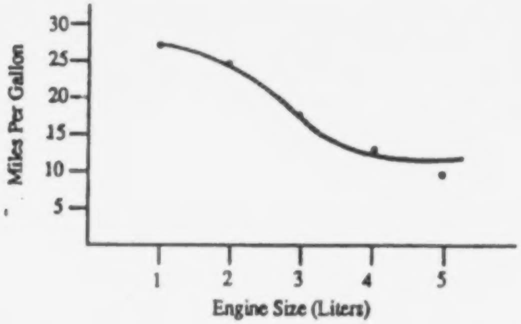


C



D

21. A consumer group measured the miles per gallon cars get with different size engines. The results are graphed below.



Which one of the following is the best description of the relationship shown on the graph?

a. The larger the engine, the more miles per gallon the car gets.
b. The fewer miles per gallon the car gets, the smaller the engine.
c. The smaller the engine, the more miles per gallon a car gets.
d. The more miles per gallon for a car, the larger the engine.

Name: ______________________________

Student ID#: __________________________

FIN TEST

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September 1987

FIN TEST

I.

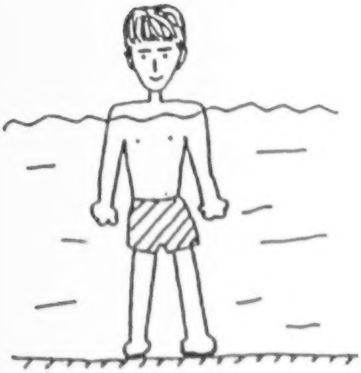

Figure A

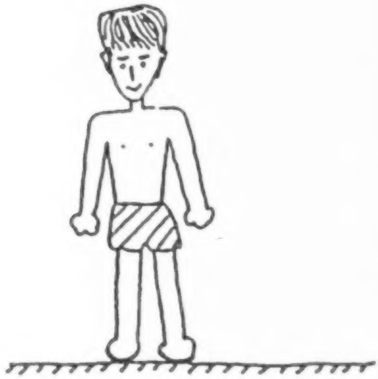

Figure B

A person stands first in a swimming pool (Figure A), then on the ground beside the pool (Figure B).

Compare the force felt on the bottom of the feet in the two Figures.

What do you think accounts for this feeling?

II.

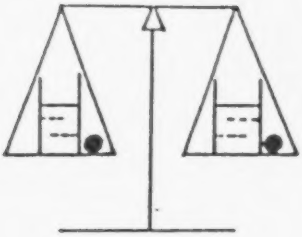

Figure C

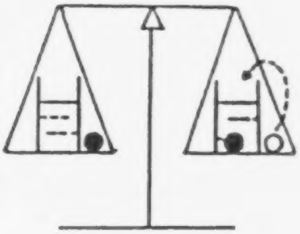

Figure D

A balance is used to compare two containers of water and two steel balls.
In Figure C the mass of the container, water, and ball on the left side just balances the mass of the other container, water, and steel ball.

Figure D shows the same system. What will happen when the steel ball on the right side of the balance is placed in the container of water on that side? Circle the number before the correct answer.

1. The right side will go down.
2. The left side will go down.
3. The beam will stay balanced.

Explain your answer.

III.

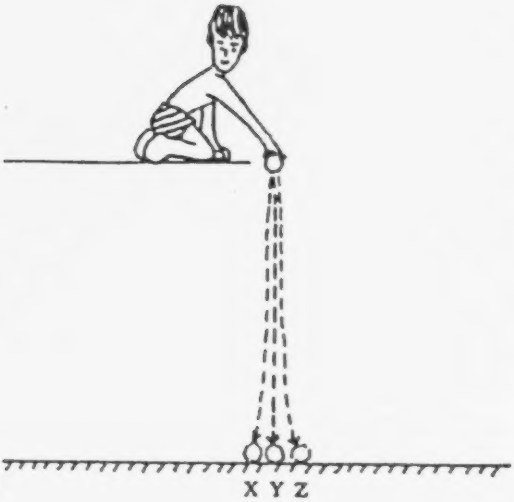

Figure E

A person kneels at the edge of a platform on a windless day and releases a steel ball as shown in Figure E.

Where will the ball appear to hit the ground? Circle the number before the correct answer.

1. Position X
2. Position Y
3. Position Z

Explain your answer using the term gravity.

IV.

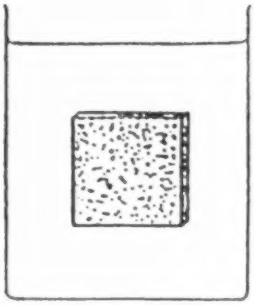

Figure F

An object floats freely at the position in a container of water as shown in Figure F.

Explain how this object can float where it does using the term force?

V.

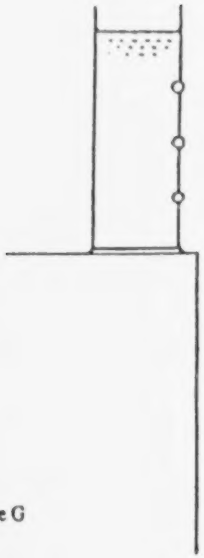

Figure G

A container filled with water has three holes bored in its side as seen in Figure G.

Draw the path that the water should take as it leaves each of the three holes.

Explain why the water takes the path you have shown.

VI.

The object in Figure H has a volume of 10 cm^3 and a mass of 70 g.

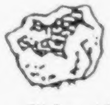

Figure H

Object (A)

Figure I shows three objects having their mass being measured on a balance.

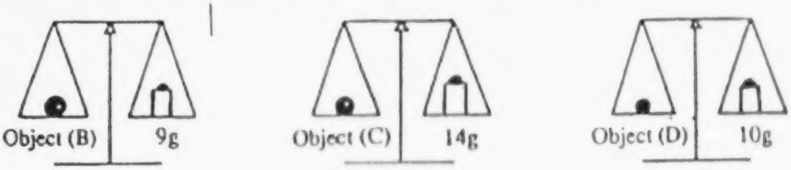
Object (B)
9g
Object (C)
14g
Object (D)
10g

Figure I

Figure J shows the same three objects have their volume being measured using a graduated cylinder. Each of the objects was put into a cylinder which had 10 cm^3 of water before the object was put into it.

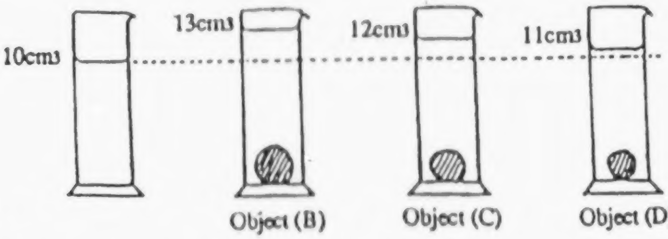
10cm3
13cm3
12cm3
11cm3
Object (B)
Object (C)
Object (D)

Figure J

One of the objects shown in Figures I and J is made of the same material as the object shown in Figure H. Circle the number of the object with the same material.

1. Object (B)
2. Object (C)
3. Object (D)

Explain your answer.

FAST TEST

Curriculum Research & Development Group
University of Hawaii

1987

FAST TEST

PHYSICAL SCIENCE EVALUATION 1

The following exercise will provide an inventory of some of the skills and concepts you have gained so far. It is divided into two parts, laboratory and desk problems.

Your teacher will instruct you about changing from laboratory to desk problems.

Write on the ANSWER SHEET ONLY.

Part I. Laboratory Problems

Be sure that your answers include the unit of measure (cm, cm^3, ml, g, etc.).

1. What is the height of the box?
2. What is the area of the base of the box?
3. What is the mass of the box and ballast? (Be sure the box is dry.) Ballast is material used to add mass to the box.
4. What volume of liquid is displaced by the box in the following situation? Float the box on the liquid in the beaker "A." Then put the ballast into the box. Determine the amount of liquid displaced.
5. What is the density of liquid in beaker "A"?
6. Which is denser, the liquid in beaker "A" or the liquid in beaker "B"? What is your evidence?

Part II. Desk Problems

Part II. A. Graph the following data. Properly label and title the graph.

Table 1 Mass of Various Lengths of Gold Wire

Length (cm)	Mass (g)
2	5
6	15
8	20
10	25

Part II. B. A box was placed in liquid "X." A record was kept of the volume of the liquid displaced and the mass of the box and contents displacing that liquid. The graph of the data is shown in Figure 1. Use this graph in answering the following questions.

Buoyancy of Liquid "X"

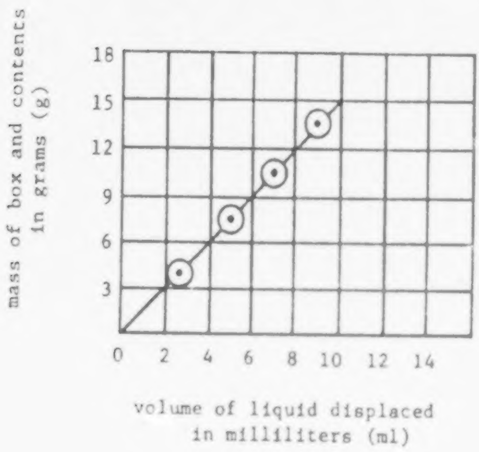

Figure 1 Graph for part II. B., questions 1-5.

1. What would be the mass of box and contents that would displace 4 ml of liquid "X"?

2. What was the mass of the box and contents that displaced 7 ml of liquid "X"?

3. What would be the volume of liquid displaced if the mass of the box and contents were 9 g?

4. Assume the box is large enough. What would be the volume of liquid displaced if the mass of the box and contents were 18 g?

5. What is the density of liquid "X"?

Part II. C. The jar and cap shown in Figure 2 have a total mass of 9 g and a volume of 12 cm^3. The cap can be removed and contents can be added.

Mass of jar (with cap) = 9 g

Volume of jar = 12 cm^3 = 12 ml

Density of water = 1 g/ml

Figure 2 Apparatus used in part II. C.

1. What would you do to get the jar to float on the surface of water?
2. What would you do to get the jar to subsurface float in water?
3. What would you do to get the jar to sink to the bottom in water?
4. What would you do to get the jar to subsurface float in liquid whose density is 2 g/ml?

科学教育における Process Skills, Reasoning 等に関する研究

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